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THE GERRIDAE (HEMIPTERA) OF BRITISH COLUMBIA

G. G. E. SCUDDER[1]

ABSTRACT

Eight species of **Gerris** are recorded from British Columbia. The distribution and co-existence is documented and a key to species is included.

INTRODUCTION

Downes (1927) has reported six species of Gerridae from British Columbia, namely *G. buenoi* Kirk., *G. incognitus* D. & H., *G. incurvatus* D. & H., *G. notabilis* D. & H., *G. remigis* Say and *G. rufoscutellatus* Latr. Drake & Harris (1934) added *G. nyctalis* D. & H. to the list and noted that *G. rufoscutellatus* did not occur in North America; this has been confirmed by Kelton (1961). Three additional species have been recorded from British Columbia in the very early literature, *G. marginatus* Say (Parshley, 1921), *G. dissortis* D. & H. (Criddle, 1926) and *G. gilletti* Leth. & Sev. (Bueno, 1925). However, these latter species have not been recognised in recent studies on the fauna of the province.

In research on the fauna of saline lakes in the interior of British Columbia (Scudder, 1969a), I have discovered two additional species that have not previously been recorded from the Province, namely *G. comatus* D. & H. and *G. pingreensis* D. &. H. It thus is appropriate to review the records of this family in British Columbia, to assess their occurrence and distribution, and to give a key to the species.

MATERIAL AND METHODS

Most of the material considered in this paper is located in the Spencer Entomological Museum at the University of British Columbia (U.B.C.). The waterbodies mentioned in the Cariboo and Chilcotin areas of the interior are listed in full in Scudder (1969a, 1969b). Additional records from insects in the Canadian National Collection (C.N.C.) have also been obtained.

RESULTS

This study has shown that eight species of *Gerris* are present in British Columbia. The records of *G. dissortis, G. gilletti, G. marginatus* and *G. rufoscutellatus* have not been confirmed.

The eight species and their distribution are as follows:

[1] Department of Zoology, University of British Columbia, Vancouver.

Gerris buenoi Kirkaldy

Gerris buenoi Kirkaldy 1911, Ent. News 22: 246 (Orig. descr.)

Gerris buenoi, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 195 (Descr.)

Gerris buenoi, Brooks & Kelton, 1967, Mem. ent. Soc. Can. 51:47 (Descr.)

A small species, recognised by the pale lateral pronotal stripe, and the short and broad genital segments. It is known mostly from macropterous specimens in B.C., but short-winged and apterous individuals also are present. The species is widely distributed in the province on small freshwater lakes and ponds. Observations on the life history of this species have been made by Hoffman (1924) and the fifth instar larva has been described by Sprague (1967).

B.C. Material examined: Brunson L., vi (G.G.E.Scudder); Boitano L., v (G.G.E.S.); Cariboo, 83 mile, v (G.G.E.S.); pothole near Boitano L., vi (G.G.E.S.); Chilcotin — Moon's L., East L., Box 17, Nr. Phal., Crescent pothole, iv-v (G.G.E.S.); Clinton, 6 mile lake, vi (G.G.E.S.); Dutch Creek, vi (G.G.E.S.); Fort St. John, vi (A. B. Acton); Kamloops, ix (G.J.Spencer); Lac du Bois area (LB3) near Kamloops, v (G.G.E.S.); Kinbasket, vi (G.G.E.S.); Loon Lake, v (G.G.E.S.); Malahat, viii, ix (W.Downes); Manning Park, beaver pond, viii (G.G.E.S.); Marion Lake, v (G. Jamieson); McIntyre Lake, vi (G.G.E.S.); Nicola, vii (G.J.S.); Osoyoos, iii (H.B.Leech); Quesnel, vi (G.J.S.); Quick, viii (G.J.S.); Saanich Distr., vi, ix (W.D.); Springhouse, v-vi (G.G.E.S.); Steelhead, ix (G.G.E.S.); Vancouver, ix (W.D.); Victoria, vii (W.D.); Westbank, ix (W.D.); Westwick Lake, v-vi (G.G.E.S.); Williams Lake Distr., v (G.G.E.S.); W. Crescent Valley, v (J. Sheppard) (U.B.C.). Creston, v (G. Stace-Smith); Summerland, iv (A.N.Gartrell) (C.N.C).

Range: a transcontinental species occurring throughout the northern part of the United States and southern Canada (Drake & Harris, 1934; Moore, 1950; Strickland, 1953; Brooks & Kelton, 1967; Cheng & Fernando, 1970). I have also seen specimens from Mile 550, Alaska Highway, 31.v.1962 (I. Stirling). Recorded previously from

Saanich by Parshley (1921) and Vancouver by Downes (1927).

Gerris comatus Drake & Harris

Gerris comatus Drake & Harris 1925. Ohio J.Sci. 25:270 (Orig. descr.)

Gerris comatus, Drake & Harris, 1934, Ann. Carnegie Mus. 23:193 (Descr.)

Gerris comatus, Brooks & Kelton, 1967, Mem. ent. Soc. Can. 51: 46 (Descr.)

This species is without a pale lateral stripe on the pronotum. The male has distinct lateral tufts of long hairs on the genital segment (segment VIII) and the female has the connexivum of segment VII not greatly incurved dorsally. Macropterous insects outnumber micropterous forms (9:1) in the B.C. material studied. The species seems to be confined to the central and northern interior of the province. The fifth instar larva has been described by Sprague (1967).

B.C. Material examined: Brunson L., vi (G.G.E.S.); Cariboo, pothole near Boitano L., vi (G.G.E.S.); Cariboo, Sorenson L., v (G.G.E.S.); Cariboo, Springhouse, v (G.G.E.S.); Cariboo, 155 mile, Old Cariboo Hwy., v (G.G.E.S.); Chilcotin, Moon's L., East Lake, v-vi (G.G.E.S.); Fort St. John, vi (A.B.A.); Stuart L., viii (G.J.S.); Vanderhoof, viii (G.J.S.); Williams Lake Distr. vi (G.G.E.S.) (U.B.C.). Rolla, vii (P.N.Vroom) (C.N.C.).

Range: from the Atlantic coast, east to Montana, being recorded from most of the intervening states (Drake & Harris, 1934). In Canada recorded from Ontario (Drake & Harris, 1934: Cheng & Fernando, 1970), Quebec (Moore, 1950), Alberta (Strickland, 1953), Manitoba, and Saskatchewan (Brooks & Kelton, 1967). Not previously recorded from B.C.

Gerris incognitus Drake & Harris

Gerris incognitus Drake & Harris 1925, Proc. Biol. Soc. Wash. 38: 73 (Orig. descr.)

Gerris incognitus, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 193 (Descr.)

A species with pale lateral stripe to the pronotum, and male with distinct lateral tufts of long hairs on the genital segment (segment VIII). Macropterous and apterous forms occur in about equal numbers in the material examined. This species has been recorded mostly in the southern parts of the province and on the west coast. However, it does occur in the Kootenays and the interior.

B.C. material examined: Cariboo, 83 mile, v (G.G.E.S.); Courtenay, ii; Galiano Is., iv (G.G.E.S.); Hat Creek, vii (G.J.S.); Kimberley, North Star Mt., slough at 4,500 ft., v (I. Stirling); Lakelse Lake, v (R. Drent); Kamloops, vi (G.J.S.) Marion Lake, v-vi, viii (J. Maynard; G.J.); Qualicum, v (W.D.); Queen Charlotte Is.: Port Clements, Tlell, iii (A.B.A.); Texada Is., Paxton L., v (G. Larsen); Vancouver, iii, v-vi (G.J.S.; G.G.E.S.; H.B.L.); W. Crescent Valley, v (J.S.) (U.B.C.) Mission City, vi (E. Mason); Mt. Revelstoke, vii (G.J.S.); Squamish, 3200 ft., viii (G.J.S.) (C.N.C.).

Dr. L. Kelton informs me that the C.N.C. also contains specimens from Rolla.

Range: A western North American species for the most part, being recorded from Washington, Oregon, California, Montana, Idaho, British Columbia (Kaslo) (Drake & Harris, 1934). However, it is also reported from Quebec (Drake & Harris, 1934; Moore, 1950). Recorded from Goldstream in B.C. by Downes (1927).

Gerris incurvatus Drake & Harris

Gerris incurvatus Drake & Harris 1925, Proc. Biol. Soc. Wash. 38: 71 (Orig. descr.)

Gerris incurvatus, Drake & Harris, 1934, Ann. Carnegie Mus. 23:192 (Descr.)

A moderate sized species, without a pale stripe laterally on the pronotum, and the male without lateral tufts of long hairs on the genital segment. The species is widely distributed in the province. Macropterous and short-winged forms have been examined and the former is most abundant in the B.C. material studied.

B.C. material examined: Endiver, vi (G.G.E.S.); Hat Creek, vii (G.J.S.); Kamloops, vi, viii (G.J.S.); Malahat, ix (W.D.); Marion Lake, iv-viii (J.M.; G.J.); Nicola, vi-vii (G.J.S.); Saanich Distr., ix (W.D.); Saanich Distr., Elk L., iv (W.D.); Vancouver, v-vi (G.J.S.; H.B.L.); Vernon, ix (W.D.); previously determined by H. B. Hungerford as *G. marginatus;* Victoria, vii (W.D.); Wellington, vi; West Vancouver, Lions Bay, v (G.J.S.) (U.B.C.). Copper Mt., v (G.S.-S.); Douglas Lake, vii (N.C.); Minnie Lake, vii (N.C.) (C.N.C.).

Material from Summerland and White Lake is also present in the C.N.C.

Range: A western species, recorded from Washington, Oregon, California, Idaho, Montana and British Columbia (Drake & Harris, 1934). Drake & Harris (1934) also record the species from Illinois. It was recorded from Saanich and Vernon by Downes (1927), who also noted that this is the species that was reported from Beaver Lake as *G. marginatus* by Parshley (1921).

Gerris notabilis Drake & Hottes

Gerris notabilis Drake & Hottes 1925, Ohio J.Sci. 25:46 (Orig. descr.)
Gerris notabilis, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 189 (Descr.)
Gerris notabilis, Brooks & Kelton, 1967, Mem.ent.Soc.Can. 51: 45 (Descr.)

A rather large and slender, somewhat rufous species, with sternum VII of male simply emarginate. It is widely distributed in the province. Drake & Harris (1934) note that the species usually inhabits streams and is only known as the macropterous form.

B.C. material examined: Adams River, viii (G.J.S.); Aleza Lake, vii (H. Barclay); Cariboo, pothole near Boitano Lake, vi (G.G.E.S.); Brunson Lake vi (G.G.E.S.); Cariboo, Springhouse, v (G.G.E.S.); Cedarvale, viii (G.J.S.); Chilcotin, v-vi (G.G.E.S.); Duncan, ix (W.D.); Endiver, vi (G.G.E.S.); Florence Lake, xi (G.M.Neal); Forbidden Plateau, viii; Goldstream, vii (K.F.Auden); Haney, ix (W.D.); Hat Creek, vii (G.J.S.); Jesse Is., vi (G.J.S.); Kamloops, vi (G.J.S.); Kinbasket, vi (G.G.E.S.); Lake Cowichan, vi-viii (R.W.Pillsbury); 5 mi. E. of Lone Butte, vii (A.Jansson); Malahat, ix (W.D.); Marion Lake, v, viii (J.M.; G.J.); McIntyre Lake, vi (G.G.E.S.); New Westminster, ix (W.D.); Nicola, vii (G.J.S.); 30 Mls. E. of Prince George, viii (G.G.E.S.); Saanich, vi (W.D.); Vancouver, v (G.J.S.); Vancouver, Mt. Seymour, vii (H.B.L.); Vancouver, Mt. Seymour, Nacy Lake, ix (R. Leech); Vernon, x (W.D.); Vanderhoof, vii (G.J.S.); Victoria, ix (G.J.S.); Walhachin, vii (E.R.Buckell); Westwick Lake (outlet of Sorenson Lake), v (G.G.E.S.); W. Crescent Valley, v (J.S.) (U.B.C.). Copper Mt., v (G.S.-S.); Keremeos, vii (J.E.H.Martin); Minnie Lake, vii (N.C.); Mission City, v (G.J.S.); Summerland, ix (A.N.G.); Vaseaux Lake, v (A.N.G.); Westbank, iv (A.N.G.) (C.N.C.).

In the C.N.C. there are specimens also from Kitimat, Mt. Adams, Mt. Revelstoke, Queen Charlotte Is., and Terrace.

Range: California, Oregon, British Columbia, Idaho, Montana, Wyoming, Utah, Colorado, Iowa (Drake & Harris, 1934), Alberta (Brooks & Kelton, 1967). Recorded from Saanich and Vernon by Downes (1927), who notes that this was reported by Parshley (1919) as *G. rufoscutellatus.*

Gerris nyctalis Drake & Hottes

Gerris nyctalis Drake & Hottes 1925, Ohio J.Sci. 25: 47 (Orig. descr.)
Gerris nyctalis, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 190 (Descr.)

This species is very similar to *G. remigis,* but the male of *G. nyctalis* has a broader keel on the genital segment: usually apterous, but macropterous individuals are known (Drake & Harris, 1934). I have not seen material of this species from British Columbia, but Dr. L. A. Kelton informs me that there is material from Yahk in the C.N.C.

Range: Idaho, Colorado, Montana, Washington, California, eastern British Columbia, Newfoundland (Drake & Harris, 1934), Quebec (Moore, 1950), Alberta (Strickland, 1953).

Gerris pingreensis Drake & Hottes

Gerris pingreensis Drake & Hottes 1925, Ohio J.Sci. 25: 49 (Orig. descr.)
Gerris pingreensis, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 194 (Descr.)
Gerris pingreensis, Brooks & Kelton, 1967, Mem.ent.Soc.Can. 51: 46 (Descr.)

A moderate sized species without long silvery hair tuft on the genital segment of the male, but with a pale lateral stripe on the pronotum and abdominal sternum VII with a median longitudinal impression. The species would seem to be confined to the interior and northern part of British Columbia. Apterous individuals seem to outnumber macropterous forms (3:1).

B.C. material examined: 45 mls. N. of Atlin, vi (A.B.A.); Boitano L., v (G.G.E.S.); pothole near Boitano L., vi (G.G.E.S.); Chilcotin: Barkley Lake, Box 17, Moon's Lake, Round-up Lake, v-vi (G.G.E.S.); Clinton (LE 4), viii (G.G.E.S.); Dease Lake, viii-ix (I.S.); Fort St. John, vi (A.B.A.); Kamloops, Lac du Bois area, v-vi (G.G.E.S.); Loon Lake, v (G.G.E.S.); Meadow Lake, v (G.G.E.S.); Nicola, vii (G.F.S.); Sorenson Lake, v (G.G.E.S.); Westwick Lake, v (G.G.E.S.) (U.B.C.)

Range: streams and lakes at higher altitudes of Montana, Colorado, Idaho, Alberta (Drake & Harris, 1934; Strickland, 1953), Alberta, Saskatchewan, Manitoba (Brooks & Kelton, 1967), Quebec (Moore, 1950), Yukon-NWT, 4.vii .1944 (P.A.Larkin). Not previously recorded from British Columbia.

Gerris remigis Say

Gerris remigis Say 1832, Heter, New Harmony: 35 (Orig. descr.)
Gerris remigis, Drake & Harris, 1934, Ann. Carnegie Mus. 23: 189 (Descr.)

Gerris remigis, Brooks & Kelton, 1967, Mem.ent.-Soc.Can. 51: 45 (Descr.)

A large and robust species, with pronotum rather brownish. It is widely distributed in the province: both apterous and macropterous forms are present, but the former predominate by far. The life history and habits of the species have been studied by Bueno (1917) and Riley (1921, 1922). This species frequents small brooks with rapid current (Sprague, 1967). The fifth instar larva is described and figured by Sprague (1967).

B.C. material examined: Alta Lake, v (J. Scudder); Cultus Lake, iv, viii, x (J. Boone; R.D.; G.G.E.S.); Cayuse River, vii (G.S. Brown); Coal Creek., 1.5 mls. S. Pt.-no-Pt., v (R.D.); Courtenay; Departure Bay, vi (G.J.S.); Hatzic Prairie, ix; Jordan River, vi (K. Taylor); Kelsey Bay, vii (G.G.E.S.); Lakelse Lake, v (R.D.); Lynn Valley, vii (H.B.L.); Marion Lake, ii, v, viii (G.J.; J.M.); Milner, viii (G.G.E.S.); Nanaimo, vi (G.J.S.); Nicola, vii (G.J.S.); Osoyoos, v (M. H. Ruhman); Paul Lake (Kamloops), viii (W. A. Clemens); Pavilion Lake, vi (G.G.E.S.); Penticton, iv (E.R.B.); 9m. and 12m., E of Princeton, iii (H.B.L.); Roberts Lake (Vancouver Is.), vii (G.G.E.S.); Royal Oak, vii (G.J.S.); Saanich Distr., x (W.D.); Salvus, viii (G.J.S.); Sweltzer Creek, iv. (R.D.); Trout Lake, x (M. Miyaona); Vancouver, viii (K.F.A.); Vernon, ix (H.B.L.); Victoria, vii (K.F.A.; G.J.S.); Walhachin, vi (G.J.S.); W. Crescent Valley, v (J.S.) (U.B.C.). Errock Lake, nr. Deroche, vii (G.J.S.); Keremeos, vii (J.E.H.M.); Mission City, vii (W.R.M.Mason); Oliver, ix (C.B.Garrett); Qualicum Bay, vi (R. Coyles); Summerland, viii (A.N.G.) (C.NC.).

In the C.N.C there is also material from Kleena Kleene.

Range: widely distributed in North America, and recorded from Canada in the north to Mexico and Guatemala in the south (Drake & Harris, 1934). Recorded previously from Vernon and Saanich by Downes (1927), and Jordan Meadows by Hardy (1949).

KEY TO GERRIDAE OF BRITISH COLUMBIA

Males

1. Venter with sternum VII simply emarginate (Fig. 1) .... *notabilis* D. & H.
— Venter with sternum VII double emarginate . .*2.*
2. Larger species (over 11.00 mm.); first genital segment with a strong keel .... *3.*
— Smaller species (under 11.00 mm.); first genital segment with a weak keel .... *4.*
3. Species 11.50 - 16.0 mm. in length and brownish on the pronotum; genital keel narrower (Fig. 2) .... *remigis* Say
—Species 11.50 - 13.0 mm. in length and quite fuscous on pronotum; genital keel broader (Fig. 3) .... *nyctalis* D. & H.
4. First genital segment with a tuft of long silvery hairs on each side of keel (Figs. 4-5) .... *5.*
— First genital segment without a tuft of long silvery hairs on each side of keel (Figs. 6-8) . . *6.*
5. Pronotum with pale stripe laterally; hairs on genital segment in a line (Fig. 4) .... *incongitus* D. & H.
— Pronotum without pale stripe laterally; hairs on genital segment in a tuft or group (Fig. 5) .... *comatus* D & H
6. Pronotum with pale stripe laterally .... *7.*
— Pronotum without pale stripe laterally; genitalia as in Fig. 6 .... *incurvatus* D. & H.
7. First genital segment as broad as long (Fig. 7); sternum VII without a median longitudinal groove .... *buenoi* Kirk.
— First genital segment longer than wide (Fig. 8); sternum VII with a median longitudinal groove (Fig. 8) .... *pingreensis* D. & H.

Female[2]

1. Pronotum laterally with pale stripe .... *2.*
— Pronotum laterally without a pale stripe ..... *6.*
2. Large and rather slender species, length 15.0-20.0 mm.; with very long legs; colour rather rufous; pale stripe on pronotum laterally, usually continuous with the rather pale posterior part of the pronotum .... *notabilis* D. & H.
— Smaller species, less than 16.0 mm. in length; pale lateral stripe to pronotum not continued posteriorly .... *3.*
3. Larger and robust species, over 11.0 mm. in length .... *remigis* Say.
—Smaller and less robust species, less than 11.0 mm. in length .... *4.*
4. Genital segment rather quadrate (Fig. 16); tergum VIII dorsally with lateral prominences (Fig. 17); small species, 7.0-8.5 mm. in length. .... *buenoi* Kirk.
— Genital segments not quadrate (Figs. 12-15) . *5.*
5. Lateral margins of anterior abdominal sterna not broadly pale, but fuscous to margin (Fig. 11); sterna very hirsute .... *pingreensis* D. & H.
— Lateral margins of anterior abdominal sterna broadly pale (Fig. 9); sterna not densely hirsute .... *incognitus* D. & H.
6. Connexival spines on segment VII, when viewed from above, greatly incurved and directed towards centre of tergum (Fig. 13) ... . *incurvatus* D & H

—Connexival spines on segment VII, when viewed from above, not greatly incurved, but directed caudad (Fig. 15) . . . . *comatus* D & H

[2]*G. nyctalis* not included.

Coexistaence in *Gerris*

Gause's Principle, Gause's Hypothesis or the Competitive Exclusion Principle holds that two species with similar ecology cannot live together in the same place indefinitely (Gilbert *et al.*, 1952; Hardin, 1960). During the course of studies on the aquatic insects of British Columbia, several localities have been found where more than one species of *Gerris* may be observed together and breeding at the same time. While the biology of these species has yet to be worked out in detail, it seems worthwhile to record the occurrence of this situation. Table I presents the localities where this coexistence has been observed, and the species involved are noted. Work now being undertaken hopefully will clarify the biological significance of this coexistence in *Gerris.*

Acknowledgments

I am indebted to Dr. L. A. Kelton for information on the Gerridae in the Canadian National Collection, and Mrs. M. D. Jensen for the illustrations. This paper results from research supported by the National Research Council of Canada.

		Species						
Area	Water body	buenoi	comatus	incognitus	incurvatus	notabilis	pingreensis	remigis
Fraser Plateau	Boitano L.	x					x	
	Westwick L.	x				x	x	
	McIntyre L.	x				x		
	Brunson L.	x				x		
	Box 17	x					x	
	Moon's L.	x	x				x	
	Boitano PH	x	x			x	x	
	LB3 (nr. Lac du Bois)	x					x	
Lower Fraser Valley	Marion L.	x		x	x	x		x

TABLE 1. Records of coexistence of species of Gerris in British Columbia. Water bodies arranged in order of decreasing salinity.

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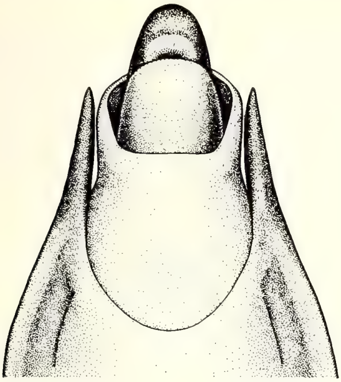
Figs. 1-8. Ventral view of genitalia of male **Gerris.** 1, **G. notabilis;** 2, **G. remigis;** 3, **G. nyctalis;** 4, **G. incognitus;** 5, **G. comatus;** 6, **G. incurvatus;** 7, **G. buenoi;** 8, **G. pingreensis.** Scale line = 1.00 mm.: colour pattern not indicated.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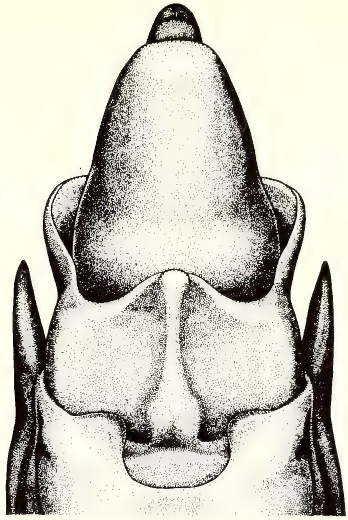
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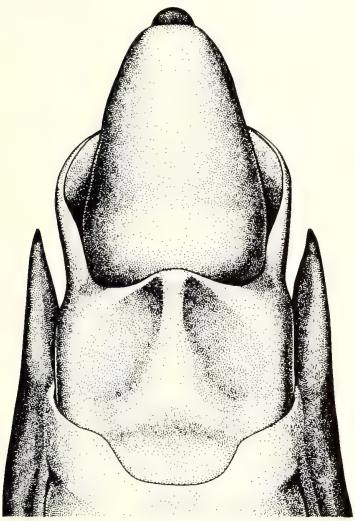
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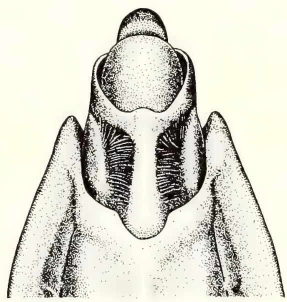
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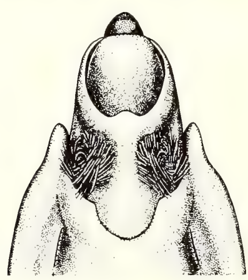
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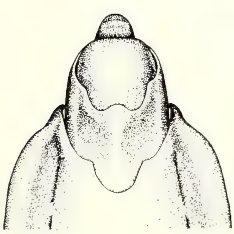
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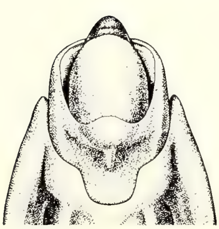
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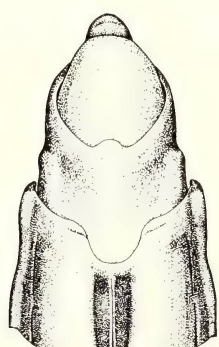
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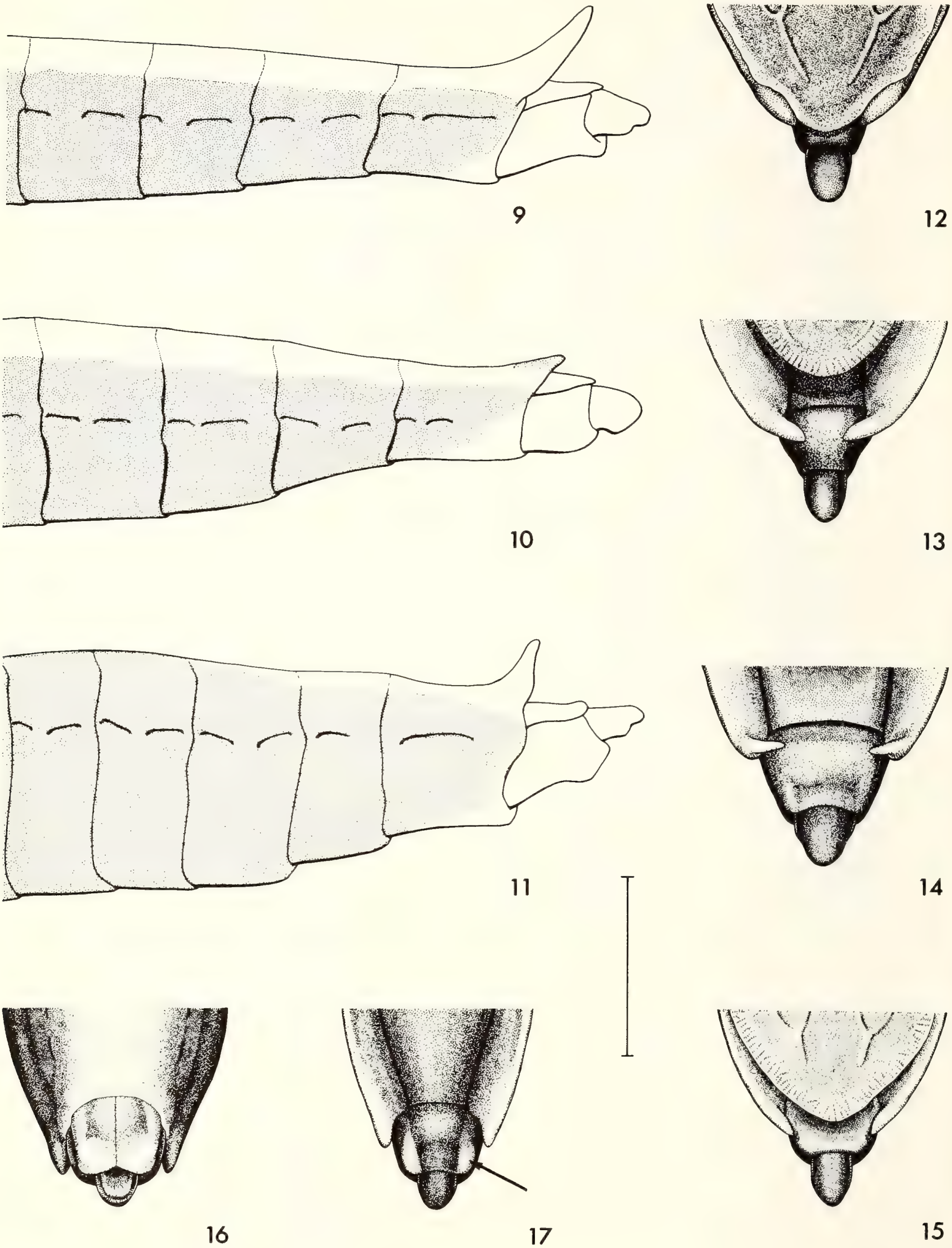

Figs. 9-17. 9-11, Side view of abdomen of female **Gerris:** 9, **G. incognitus;** 10, **G. incurvatus;** 11, **G. pingreensis.** 12-15, dorsal view of terminal part of abdomen of female **Gerris:** 12, **G. incognitus;** 13, **G. incurvatus;** 14, **G. pingreensis;** 15, **G. comatus.** 16-17, structure of end of abdomen in female **G. buenoi:** 16, ventral view; 17, dorsal view. Scale line = 1.00 mm.: colour pattern shown only on pregenital segments in Figs. 9-11.

A PROGRESS REPORT ON THE USE OF FEMALE-BAITED TRAPS AS INDICATORS OF CODLING MOTH POPULATIONS [1]

H. F. MADSEN AND W. W. DAVIS

Research Station, Canada Department of Agriculture,
Summerland, British Columbia.

ABSTRACT

Traps containing live female codling moths, **Laspeyresia pomonella** (L.), as lures were used to indicate native codling moth populations in 2 orchards in the Kelowna area of British Columbia. In one orchard the traps captured an average of fewer than 1 male codling moth per week with the exception of 2 traps along one side of the orchard. These 2 traps caught 45 per cent of all males trapped in the orchard, and codling moth entries were found in this vicinity. A spray to control codling moth was applied to 4 outside rows of trees on this side but the remainder of the orchard was not sprayed. No fruit injured by codling moth was found in the nonsprayed portion of the orchard. In the second orchard the traps captured an average of 5 moths per week. No sprays were applied to the trees and, at harvest, 9.3 per cent of the apples were injured by codling moth. These preliminary data indicate that traps baited with female codling moths can be used to indicate levels of codling moth populations and also to indicate if chemical control is necessary.

INTRODUCTION

Developments in the field of insect sex pheromones has led to a number of practical uses for these lures. They have been employed to reduce pest populations (Guerra, Garcia and Leal 1969) and as survey tools to detect low pest populations (Dean and Roelofs 1970).

Sex traps as a lure for male codling moths, *Laspeyresia pomonella* (L.), are baited with either live female codling moths (Proverbs, Newton and Logan 1966) or extracts of the female abdomens (Butt and Hathaway 1966). They have been used to time spray applications, to assess field activity of the moths (Batiste 1970), and to provide information on the ratio of sterile to native moths in a program of control by the sterility method (Proverbs, Newton and Logan 1969). One area which has received little attention is the use of sex traps to determine population levels of codling moth and to estimate the potential fruit damage at harvest. With such information, a grower could judge whether a spray is warranted and thus base his codling moth control program on need rather than on a routine preventative schedule. The first step taken to obtain information of this nature was to install female-baited traps in locations where sprays were not applied and then attempt to correlate moth capture with the infestation at harvest. This paper reports our first study of the use of sex traps to establish a population level for the codling moth.

[1] Contribution No. 318, Research Station, Summerland, British Columbia.

MATERIALS AND METHODS

The codling moth pheromone traps used in this study were similar to those described by Proverbs, Newton and Logan (1966), and each trap contained 10 virgin females. As little data were available on how many traps should be installed to assess a codling moth population, the figure of 1 per acre was chosen based on field experience from the codling moth sterility program (Proverbs, Newton and Logan 1969) and on the availability of manpower to maintain trap records. Two orchards were used in the study; one was a grower-operated planting (Price orchard) and the other an experimental orchard (Substation) operated by the Canada Department of Agriculture. Both orchards were located at Kelowna, B.C.

The Price orchard is a mixture of young and old trees on a rectangular shaped area of approximately 15 acres. The largest planting within the orchard is a block of mature McIntosh apple trees 15 rows deep by 10 rows wide, and a block of medium sized Red Delicious trees 27 rows deep by 19 rows wide. The McIntosh trees are bordered on the north by a mixed planting of young Golden and Red Delicious trees (8 rows long by 18 rows wide) and on the south by approximately 2 acres of newly planted, nonbearing trees. The orchard is in the center of a commercial apple producing area. All the adjoining orchards are routinely sprayed for codling moth control. The area was carefully searched for abandoned trees that might provide a source of codling moths, but none were found within a mile of the Price orchard. Price

had not sprayed his orchard for codling moth control for 3 seasons, and he stated that his packinghouse records did not show codling moth damage during this three year period. A total of 15 pheromone traps were placed in the orchard so that they were uniformly distributed amongst the bearing trees.

The Substation orchard consisted of 5 acres of mature McIntosh and Spartan apple trees which had not been sprayed for codling moth control for 3 years. The per cent infestation at harvest in 1967 and 1968 was 9.7 and 26.8 respectively. In the winter of 1968-1969, temperatures dropped to a low of -32 C. which caused a high mortality of overwintering codling moth larvae. As a result, the 1969 harvest infestation was only 3.7 per cent. Five traps were placed in the orchard, distributed evenly among the trees.

The traps were collected weekly, and replaced by others containing recently emerged virgin females. Captured male codling moths were counted and recorded in the laboratory.

The infestation at harvest was determined by examining samples of apples for the number of codling moth entries and stings. At the Price orchard, it was not possible to obtain harvest samples in the field, and the codling moth injury was determined by examining the culls after the fruit was graded in the packinghouse. At the Substation, the harvest sample consisted of 5 boxes per tree on 20 trees selected at random from the test area

RESULTS AND DISCUSSION

Male codling moth activity as determined by sex trap catches for the two orchards is illustrated in Fig. 1. The flight periods of the moths were similar in the 2 trap locations, but more moths were captured at the Substation. A seasonal average of 82 moths per trap were captured at the Substation compared with 31 at the Price orchard. The majority of the moths at the Price orchard were recorded from 2 traps along the south end of the McIntosh block. Forty-five per cent of the total moths were captured in this portion of the orchard. The population peaked from mid-July to mid-August and, based upon previous flight data, these moths were probably second brood. The orchard had been examined for first brood entries prior to this time, but none was found. At the Substation, however, first brood entries were relatively common.

When the 2 traps in the Price orchard showed relatively high numbers of moths in mid-July the fruit throughout the orchard was carefully checked for second brood entries. Infested fruit was found only in the McIntosh trees and most of this was along the south edge of the block. The entries were found in groups which indicated activity by relatively few females. The first entries were found on 21 July, and the number of infested fruits increased through late July and early August. All infested apples observed in the field were collected and dissected. Each contained early instar larvae which was further evidence that the infestation was due to second brood activity. Because the number of entries were increasing, the grower treated the outside 4 rows of the McIntosh block along the south side with azinphosmethyl in August. No further entries were observed for the remainder of the season.

Since so many moths were captured along the south end of the McIntosh trees, it seemed likely that they originated outside the Price orchard. Almost all of the entries were found along the side which adjoined 2 acres of nonbearing, recently planted trees.

An examination of cull fruit from the Price orchard did not show any apples infested with codling moth. This does not suggest the harvest infestation was zero, as pickers often discard fruit that is obviously wormy. The data do indicate that the infestation was very low and would not have justified a routine codling moth spray. If the high counts in the 2 traps in the McIntosh trees are omitted, the total seasonal moth catch per trap in the rest of the orchard would be 17, or less than 1 moth per trap per week. By contrast, the weekly catch in the Substation orchard was 5 per trap.

At the Substation, second brood codling moth entries were evident by the end of July and fresh damage was observed throughout August. The harvest examination showed that 9.3 per cent of the apples were injured by codling moth.

Our preliminary investigations suggest that traps baited with female codling moths can be used to indicate levels of codling moth populations and whether control measures are necessary. In the Price orchard the majority of the traps caught less than one moth per week, and this population did not result in significant fruit loss. The relatively high population indicated by the traps in one section of the orchard necessitated a spray, and this was the only treatment required for pest control in the orchard. Such a program represents a considerable saving to the grower when compared with a conventional schedule.

More information is required before sex traps can be used with confidence to indicate codling moth population levels. The traps capture only males, and data are needed on female activity. It is difficult to determine whether males attracted to female-baited traps originate in the orchard where the traps are located or come from a more distant source. Proverbs (unpublished data) has shown that marked male moths can travel for a distance of 4 miles from their release site. There are indications that sex traps do not accurately reflect population levels when codling

moth numbers are high (Howell, U.S.D.A., Fruit Insects Laboratory, Yakima, Washington, personal communication). The optimum number of traps per unit area is not known nor has the best distribution of traps within an area been determined. Data thus far obtained, however, indicate that codling moth sex traps show promise for determining population levels and periods of moth activity in the field.

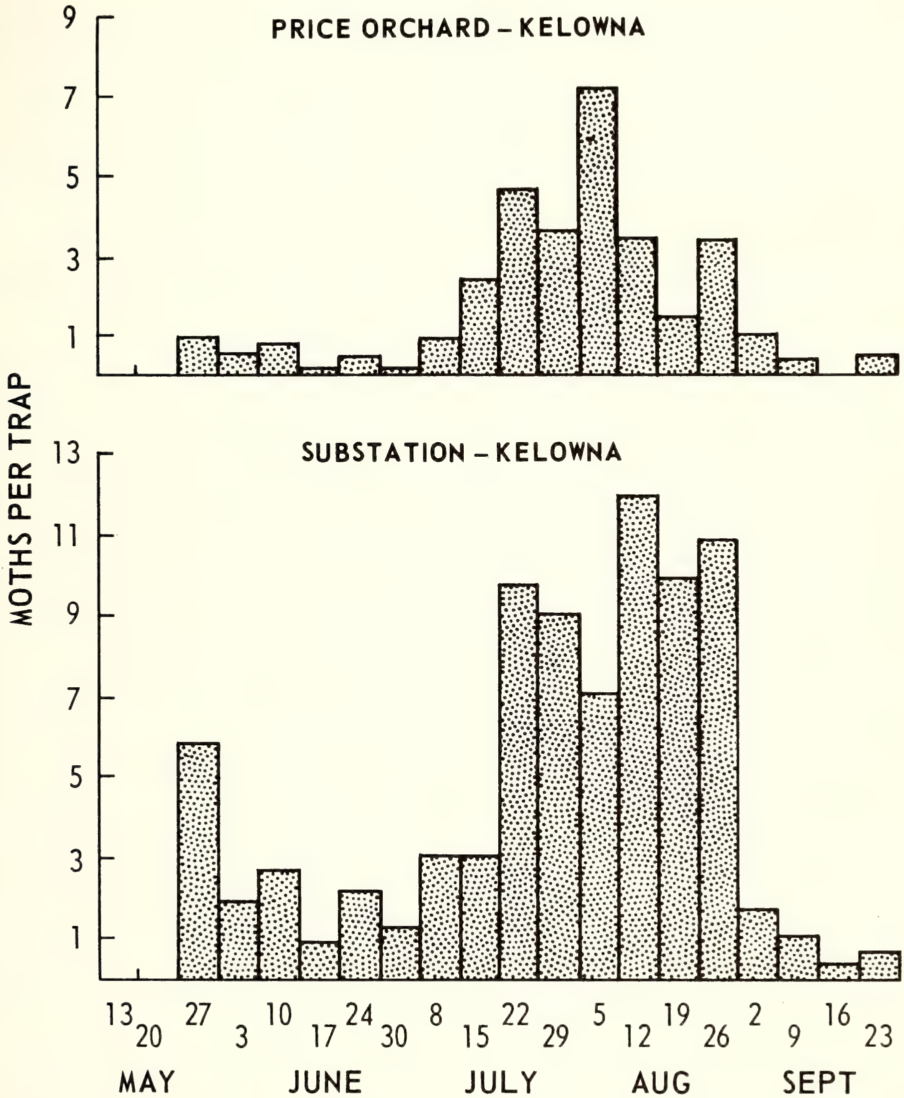

Fig. 1. Male codling moths captured in female-baited traps at the Price and Substation orchards, Kelowna, B.C. 1970.

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TOXICITY OF INSECTICIDES TO TWO STRAINS OF *HYLEMYA PLATURA* (MEIG.) (ANTHOMYIDAE: DIPTERA)[1]

D. G. FINLAYSON AND C. J. CAMPBELL

ABSTRACT

Using the topical-application and impregnated-paper methods baseline toxicity data were obtained for male and female flies of a susceptible and a cyclodiene-insecticide resistant strain of the seed-corn maggot, **Hylemya platura** (Meig.). As shown by topical application the resistance factor with dieldrin for male and female flies was 337.8 and 342.7 respectively. However, the LC_{50} by exposure to dieldrin-impregnated papers could not be obtained for the resistant strain at the concentrations tested. There was no cross-resistance to six other insecticides: two from each of the major groups of organocarbamate, organochlorine, and organophosphorous insecticides. Both methods are useful for determining the toxicity of insecticides and offer ways for agriculturists to determine if spray practices have failed or were faulty, or if resistance is developing within a species.

INTRODUCTION

Infested onions were collected at Victoria, British Columbia in August, 1964 to establish a colony of onion maggots (*Hylemya antiqua* (Meig.)) resistant to cyclodiene insecticides. These collections yielded two species of flies: one was the onion fly; the other, somewhat smaller, was identified by the late Dr. J.G.T. Chilcott, of the Entomology Research Institute, Ottawa, as the seed-corn maggot, (*Hylemya platura* (Meig.) = *Hylemya cilicrura* (Rond.)). The onion seed had been treated with aldrin, which suggested that the smaller flies might also be resistant to the cyclodiene group of the organochlorine insecticides.

In 1961 Begg reported resistance of this type in two closely related species of root maggots, *H. cilicrura* and *H. liturata* which feed on flue-cured tobacco in southwestern Ontario. Laboratory tests at Chatham, Ontario (Harris *et al.*, 1962) with field-collected adults and comparison with laboratory-reared flies of the Chatham susceptible strain of *H. platura*, indicated that the field-collected flies were resistant to dieldrin but susceptible to diazinon. Although it was reported by Miller and McClanahan (1960) that the ratio of *H. platura* to *H. liturata* averaged 9:1 in 1958, by 1961 *H. liturata* had become the dominant species (Harris *et al.*, 1962). Attempts by Telford and Brown (1964) to compare the degree of dieldrin resistance in the two species with laboratory-reared flies proved unsuccessful. Not only were they unable to rear *H. liturata* but *H. platura* reared from collections made at Delhi proved to be as susceptible as the Chatham strain. *H. liturata* field-collected from St. Thomas and Delhi were highly resistant.

Preliminary tests (Finlayson and Noble, 1964)

[1] Contribution No. 221 Research Station, Research Branch, Canada Agriculture, 6660 N.W. Marine Drive, Vancouver 8, British Columbia.

by exposing laboratory-reared flies from the Victoria source, to papers impregnated with several insecticides indicated that both males and females were resistant to dieldrin, but susceptible to diazinon and malathion. Concurrently, Harris *et al.*, (1966) obtained evidence of a low level of resistance to cylodiene insecticides in *H.platura* from the tobacco-growing areas of southwestern Ontario. More recently seed-corn maggot resistance to aldrin has been reported in Illinois (Harris, 1969).

For this experiment the susceptible strain of flies from Chatham was obtained from Dr. C. R. Harris and colonies of the Victoria and Chatham strains were reared in the laboratory to compare methods of application and the degree of toxicity of selected insecticides representing the major groups: organocarbamates, organochlorines, and organophosphorus compounds. Two methods of application were chosen; topical application to determine the median lethal dose LD_{50} for male and female flies for both strains and the impregnated-paper method, developed by the WHO for mosquitoes, to provide a simple method suitable for tests by agriculturalists. This paper reports the findings.

MATERIALS AND METHODS

Mass rearing of *H. platura* flies

Adults were maintained in cages approximately 60 x 60 x 60 cm with clear plastic on the sides and top, lumite plastic screen at the rear, and the front fitted with a small access port within a large door, (Fig. 1). The small port, with plastic screen, allowed movement of air and served for adding food and for adding or withdrawing oviposition pots.

Adult food was a 5% sugar solution in a 125 ml Erlenmeyer flask stoppered with a wick of shredded paper towelling; a mixture of molasses and condensed milk, 1:6, poured over bread in a 10 cm petri dish; and a dry mixture of Brewers' yeast, yeast hydrolysate, and soya flour, 3:1:3, spread in the bottom of a shallow 10 cm petri dish. Pollen was added to the dry mixture whenever it was available.

The breeding population was maintained at approximately 150 flies per cage and the conditions in the rearing room were maintained as close to optimum as possible: day temperature, 24°C; night temperature, 21°C; photoperiod 16 hours; and relative humidity 50-75% (Harris *et al.*, 1966).

Ovipostion pots were new one-pint (0.5 liter) ice cream containers. The pots were one-third filled with a moist peat-sand mixture (1:1), five or six 2 to 3-cm cubes of potato were added and covered with a paste of soybean flour, Brewers' yeast, and wheat flour (1:1:1), covered with the peat-sand mixture to two-thirds full, seeded with 10 to 15 dwarf pea seeds and 20 to 30 oat seeds, then covered lightly with the peat-sand mixture and kept moist. Oviposition pots were removed in four to seven days and placed in a holding cage similar to the oviposition cage, to allow development.

Flies were withdrawn from the holding cages at three to four day intervals, with a vacuum aspirator into a 1000 ml Erlenmeyer flask with a 2 cm foam pad at the bottom of the flask, held with food for 24 hours, then used for toxicity experiments. The flies tested were thus two to five days old. Surplus flies were used to determine dosage ranges and for maintinaing the colony.

Topical Application

Stock solutions were prepared by dissolving in acetone a known amount of the insecticide, of pure or technical grade. The test solutions were prepared either by serial dilution or dilution of aliquots from the stock solution. From preliminary trials to determine the approximate LD_{50}, five levels of dosages were prepared; two above, two below and the estimated median lethal dose. These doses should cause 10-90% mortality.

Impregnated Papers

Papers from two sources were used. From the WHO came papers with dieldrin or DDT dissolved in risella oil and malathion in olive oil-lonol CP. Prepared at this laboratory were papers with diazinon, in corn oil-acetone (1:2), and lindane in risella #17-trichlorethylene (1:1). Dieldrin-impregnated papers using the risella #17-trichlorethylene solvent were also prepared and tested at the laboratory. We used No. 1 Whatman filter papers, 15 cm square, which we prepared by moistening with 2 ml of the solution, the paper being held on a bed of nails. After partial drying they were attached with clips to a line in a fume hood to dry for 24 hours. The preliminary trials provided information for the range of papers needed. The papers were labelled and dated prior to treatment so that old papers would not be used.

Treatment of the flies

Two- to five-day-old flies were provided with 5% sucrose for 24 hours after removal from the emergence cage. Each replicate consisted of at least 120 flies, which were immobilized with carbon dioxide and sexed. Each replicate consisted of 10 males and 10 females for each range of the test insecticide and the same for an untreated control. With topical applications the solution was administered by two methods: by a calibrated micrometer through a # 26 hypodermic needle bent at right angles and

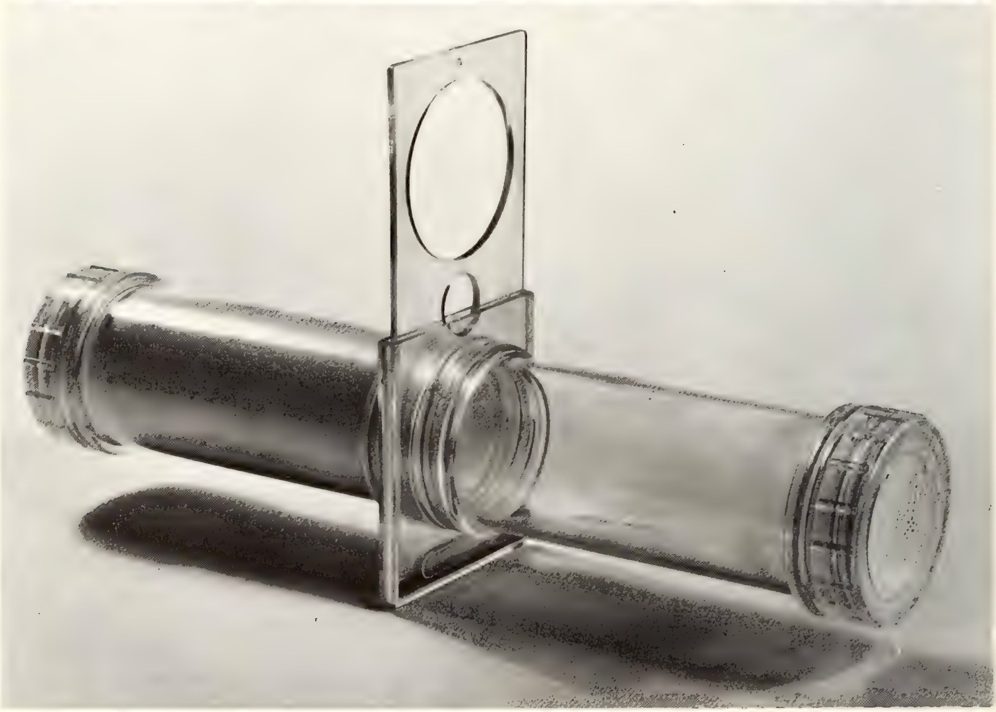

Fig. 1. Cages used for rearing large numbers of seed-corn maggot **Hylemya platura** (Meig.).
Fig. 2. WHO plastic tubes separated by slide-bar with hole exposed; Left, exposure tube with impregnated paper; Right, holding tube.

filed square at the tip, fitted to a syringe in a Syringe Microburet Model No. SB2[1]; and by a micro-pipette[2]. The standard dosage of 1 μl was applied to the dorsum of the thorax of the anesthetized fly and the 10 flies per dosage were placed in a plastic tube closed at each end with a screw cap fitted with plastic screening. Control flies were treated in the same manner, with 1 μl of acetone. When all the flies for a replicate had been treated they were held for one hour in the treatment area to ensure recovery of the control group from the anaesthetic. They were then transferred to the holding area for 24 hours under controlled temperature of 22 $\pm$ 2°C, relative humidity 50-60% and continuous lighting. To reduce variability the order of treatment was varied so that each group was subject to long and short periods of anaesthesia. To avoid toxic effects from carbon dioxide the flies were never held under anaesthesia for more than 30 minutes.

Impregnated papers were inserted with the treated side inward in WHO plastic tubes which were fitted with a slide bar (Fig. 2), and the 10 male or female anaesthetized flies were placed in the exposure tube. One hour later the flies were transferred to the holding tube through the hole in the slide-bar.

The exposure tube was removed and the treated flies in the holding tube placed in the holding area for 24 hours.

Percentage mortality was recorded 24 hours after treatment. The criterion for death was inability to walk or fly. When mortality in the control group exceeded 20 percent the results for the complete replicate were discarded. Five replicates for each insectcide were tested, with male and female flies from both strains. Percentage mortality for each insecticide was corrected using Abbott's formula (Abbott, 1925).

Results from the topical application were averaged and the slope, LD_{50} in μg/g of fly (ppm), and the fiducial limits were calculated in accordance with Finney (1962). The resistance factor (LD_{50} Victoria strain / LD_{50} Chatham strain) was calculated for both sexes and each insecticide.

Results from the impregnated-paper method were averaged and graphs prepared by line of best fit and the LC_{50} (median lethal concentration) read from the graphs. The resistance factor (LC_{50} Victoria strain/LC_{50} Chatham strain) was calculated where possible.

[1]Micro-Metric Instrument Co., Cleveland, Ohio.

[2]Drummond Scientific Co., Bromall, Pa.

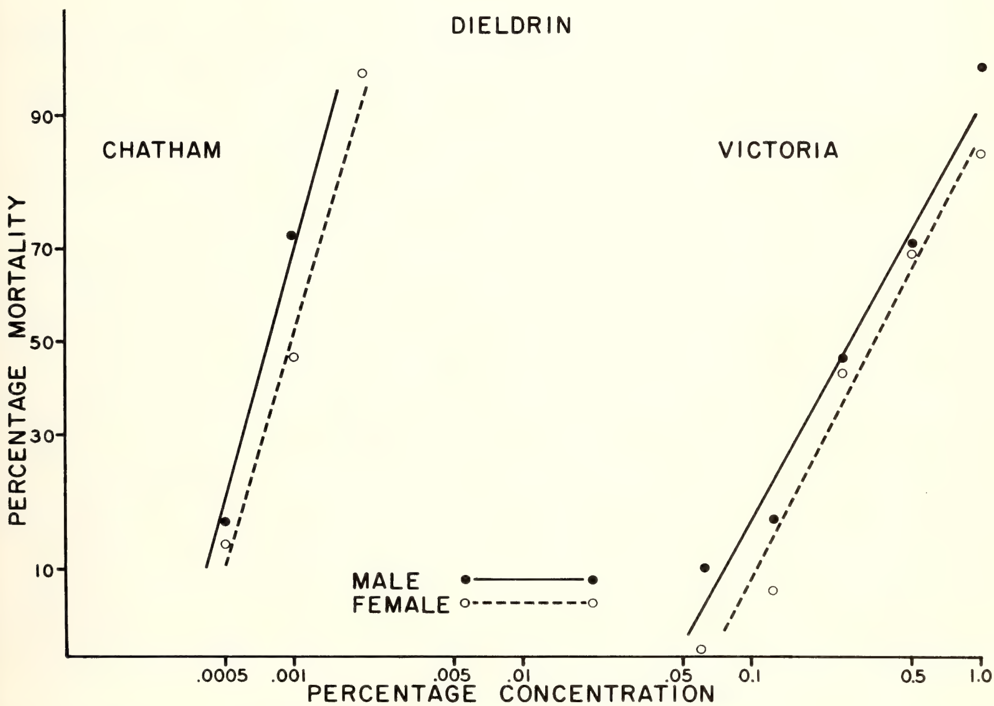

Fig. 3. Dosage-mortality regression lines, determined by topical application of dieldrin, for male and female **Hylemya platura** Chatham and Victoria strains.

TABLE 1. Toxicity of selected insecticides by topical applications to male and female flies of two strains of **Hylemya platura.**

Treatment, Strain of flies	Male				Female			
	Slope, SE of regression line	LD_{50} µg/g fly	Fiducial limits of LD_{50}	Resistance factor Vict./Chat.	Slope, SE of regression line	LD_{50} µg/g fly	Fiducial limits of LD_{50}	Resistance factor Vict./Chat.
Carbofuran								
Victoria	3.48 ± 0.61	1.36	1.00 -1.64	0.43	2.85 ± 0.40	1.58	1.16 - 1.94	0.50
Chatham	2.61 ± 0.34	3.18	2.65 - 3.81		2.69 + 0.34	3.15	2.65 - 3.76	
Carbaryl								
Victoria	2.26 ± 0.32	21.09	17.13 - 25.81	0.38	2.35 ± 0.32	25.12	20.63 - 30.76	0.28
Chatham	3.25 ± 0.39	75.58	64.52 - 88.13		2.64 ± 0.38	90.80	75.47 -110.61	
DDT								
Victoria	2.09 ± 0.24	45.94	37.69 - 56.44	3.23	2.20 ± 0.26	67.12	55.32 - 84.22	3.41
Chatham	4.38 ± 0.60	14.24	12.46 - 16.33		2.96 ± 0.56	19.70	16.30 - 26.15	
Diazinon								
Victoria	6.34 ± 0.86	0.81	0.73 - 0.90	1.05	7.48 ± 1.06	0.76	0.69 - 0.83	0.86
Chatham	3.53 ± 0.52	0.78	0.65 - 0.90		8.89 ± 0.68	0.88	0.83 - 0.95	
Dieldrin								
Victoria	2.35 ± 0.25	422.22	351.54 - 509.58	337.78	2.55 ± 0.27	500.30	421.60 - 598.96	342.67
Chatham	4.64 ± 0.57	1.25	1.06 - 1.43		4.29 ± 0.58	1.46	1.28 - 1.67	
Lindane								
Victoria	3.19 ± 0.38	20.47	17.50 - 23.92	3.44	3.42 ± 0.41	18.61	15.97 - 21.61	2.18
Chatham	2.86 ± 0.38	5.95	5.01 - 7.15		3.09 ± 0.53	8.54	7.18 - 10.71	
Malathion								
Victoria	3.75 ± 0.43	3.24	2.83 - 3.76	1.05	3.48 ± 0.41	2.62	2.26 - 3.06	0.93
Chatham	3.90 ± 0.47	3.06	2.67 - 3.54		4.90 ± 0.52	2.83	2.52 - 3.18	

Results and Discussion

Table 1 shows that male and female flies of the Victoria strain were respectively 337.8 and 342.7 times more resistant to dieldrin than the susceptible strain from Chatham. However, males and femals of the two strains were more or less equally susceptible to carbaryl, carbofuran, DDT, diazinon, lindane and malathion. The resistance factor ranged only from 0.28 for carbaryl to 3.44 for lindane. McLeod *et al.*, (1969) reported a resistance factor of 727 for aldrin in a strain of *H. platura* from Delhi near Chatham, but like ourselves, they also reported no cross-resistance to DDT and diazinon. Diazinon was the most toxic insecticide tested; the LD_{50} for both male and female flies for the two strains was less than 1.0 µg/g fly.

When we examine the dosage-mortality regression lines for topical applications (Fig. 3-6) it is quite obvious that the patterns of susceptibility for male and female flies of the same strain are similar. In all cases the lines are close and parallel or form a very shallow cross, the angle of intersection never exceeding 10 degrees. The regression lines (Fig. 3) for dieldrin inidicate that the Chatham strain is homozygous susceptible and that the Victoria strain is homozygous resistant. The slightly higher LD_{50} for lindane and DDT with the Victoria strain can hardly be interpreted as development of resistance. Nor can resistance be suspected in the Chatham strain where slightly more carbaryl and carbofuran had to be applied. These would appear to be merely strain characteristics.

The dosage-mortality curves from the impregnated paper method for 5 of the 7 insecticides are shown in Fig. 7. From this figure the LC_{50} values were read for both sexes of each strain for 4 of the 7 insecticides and the resistance factors were calculated (Table 2).

The resistance factors for the organophosphorus insecticides, diazinon and malathion, were similar by both methods. When the resistance factors were calculated for the organochlorine insecticides, DDT was 5.1 times higher by the impregnated paper method than by topical application, and lindane was 4.6 times. The resistance factor for dieldrin was hardly calculable because mortality to the Victoria strain from exposure to 4% papers was only 8.2% for males and 6.1% for females. In all probability the absorbed insecticide was detoxified.

TABLE 2. Toxicity of selected insecticides on male and female flies of two strains of **Hylemya platura** exposed to impregnated papers.

Insecticide	LC_{50} of strains of flies		Resistance factor Vict./Chat.
	Victoria	Chatham	
DDT			
male	2.10	0.114	18.42
female	2.60	0.165	15.75
Diazinon			
male	0.0275	0.0335	0.82
female	0.0390	0.0360	1.08
Dieldrin			
male	-	0.0094	-
female	-	0.0135	-
Lindane			
male	0.105	0.0096	10.94
female	0.095	0.020	4.75
Malathion			
male	1.20	1.10	1.09
female	1.20	1.94	0.62

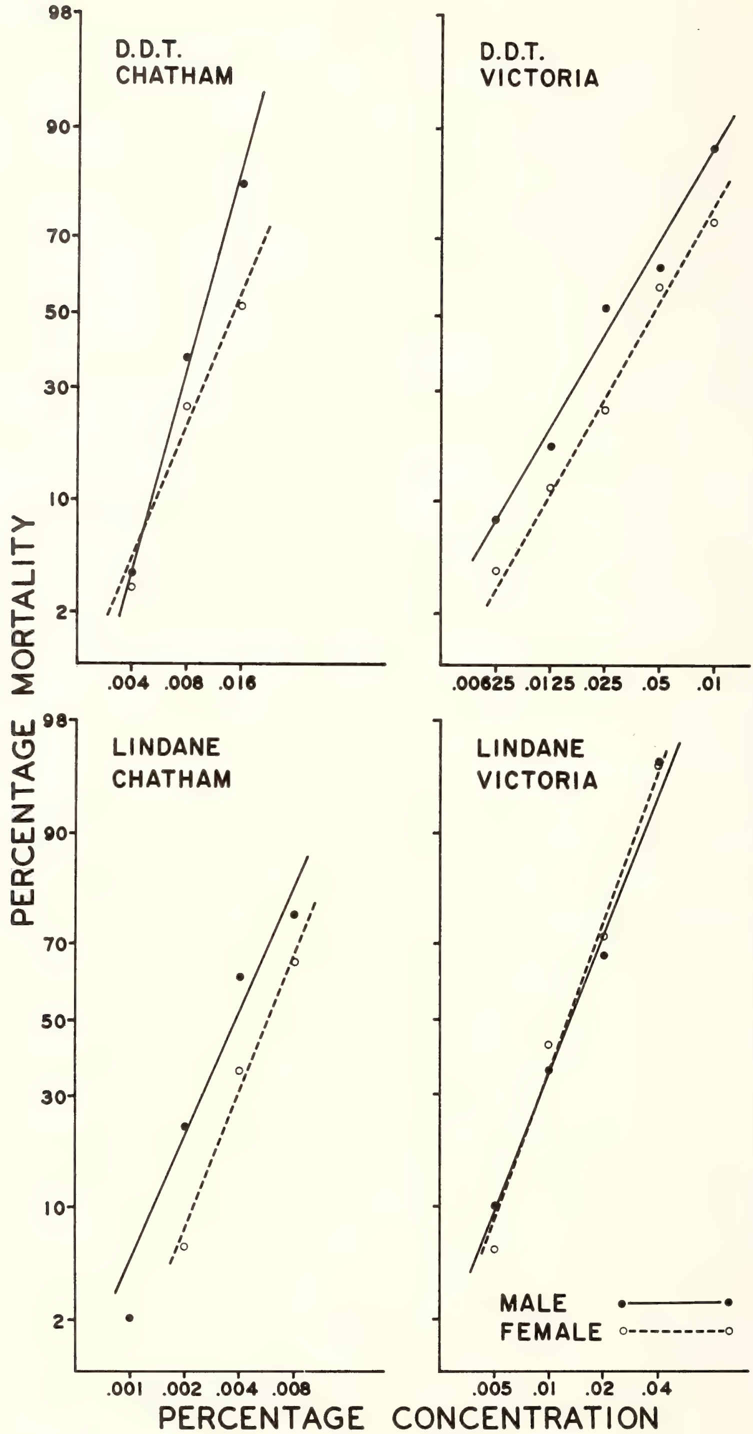

Fig. 4. Dosage-mortality regression lines, determined by topical application of organochlorine insecticides, for male and female **Hylemya platura** Chatham and Victoria strains.

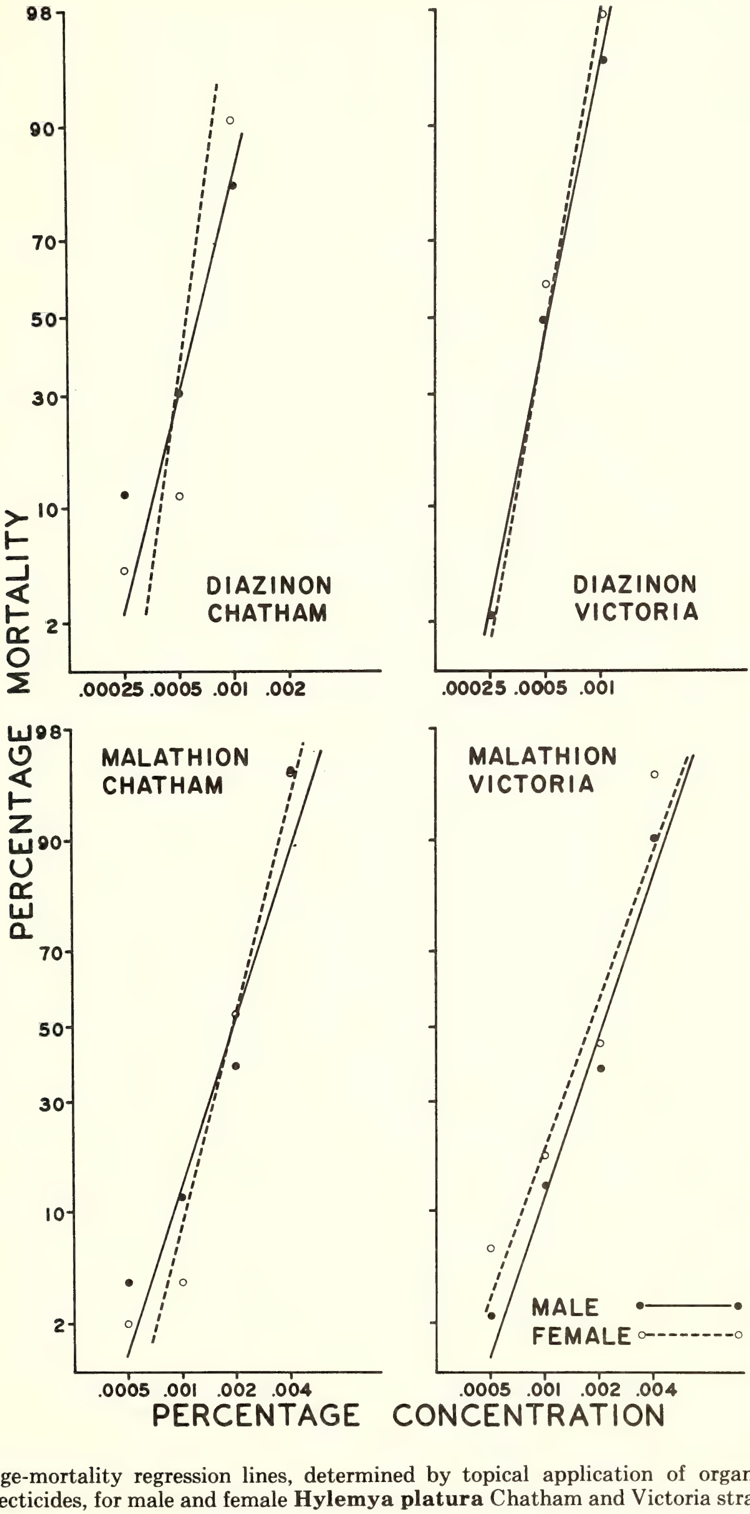

Fig. 5. Dosage-mortality regression lines, determined by topical application of organophosphorous insecticides, for male and female **Hylemya platura** Chatham and Victoria strains.

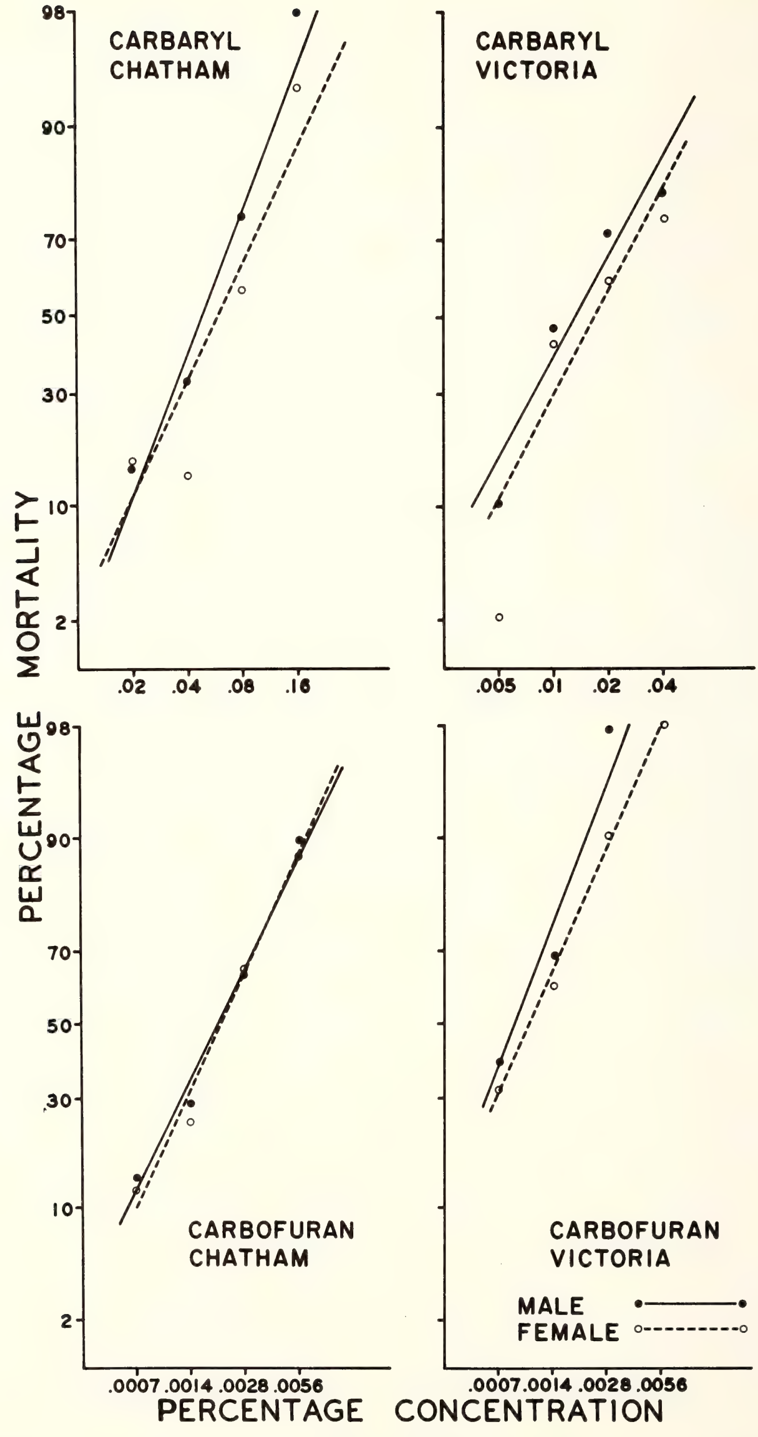

Fig. 6. Dosage-mortality regression lines, determined by topical application of organocarbamate insecticides, for male and female **Hylemya platura** Chatham and Victoria strains.

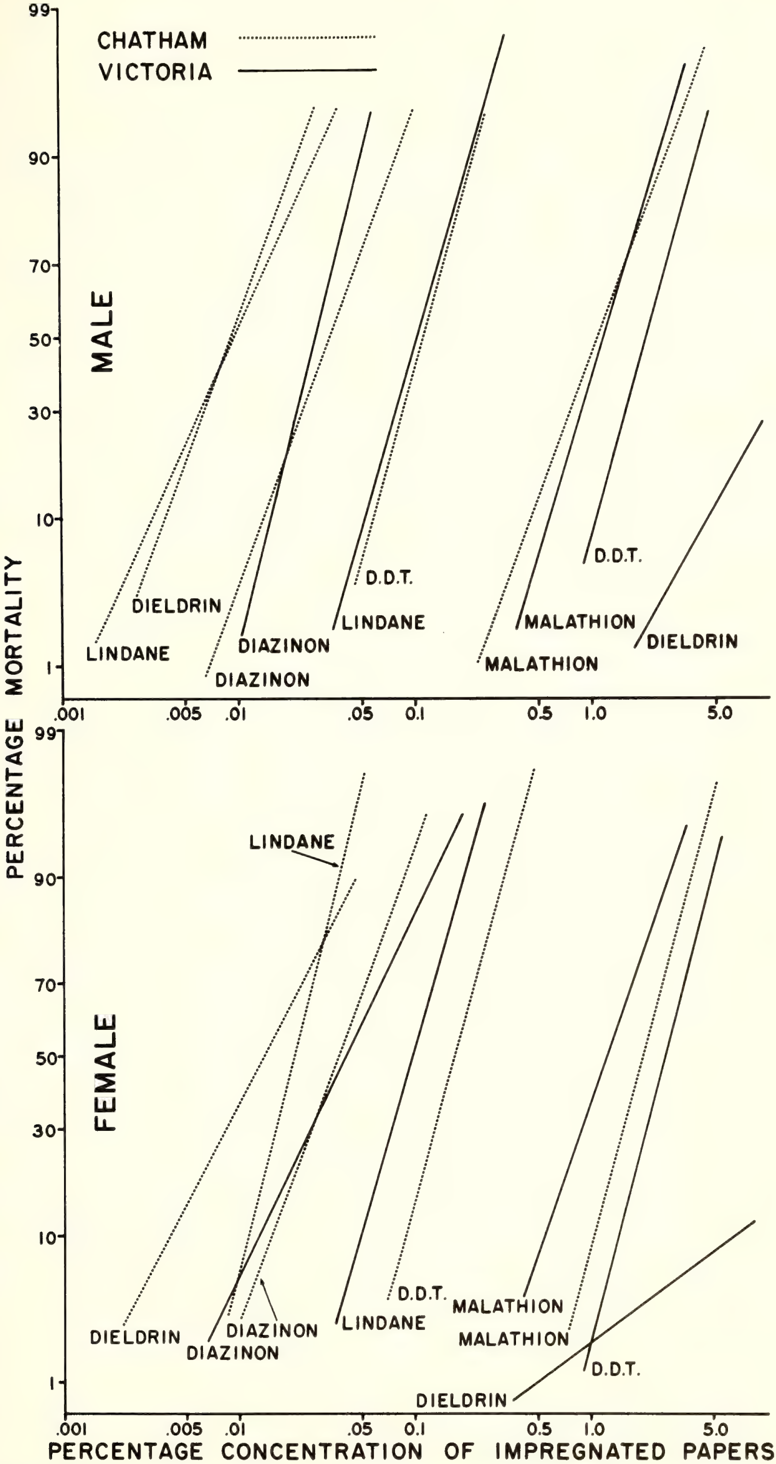

Fig. 7. Regression lines for five insecticides determined by exposure of male and female **Hylemya platura,** Chatham and Victoria strains, to impregnated papers.

We were unable to determine the LC_{50} for the organocarbamate insecticides which automatically prevented the calculation of resistance factors for the two strains. When the Victoria strain of flies was exposed to carbaryl impregnated papers, higher mortality was recorded from 1 or 2% papers than from 4% papers. When the Chatham strain was exposed to carbaryl papers, 50% mortality was not reached even with 20% impregnated papers. Exposure to carbofuran papers presented similar difficulties. Knockdown in both species occurred at various concentrations. However, by the end of the 24-hour holding period from 90-100% of the flies had recovered. The effects of topical applications were similar but to a lesser degree. At the concentrations applied topically all flies were immobilised one hour after treatment, but 24 hours later many had recovered, as shown by the dosage-mortality regression lines. Detoxification of carbofuran within the flies appears to be the only explanation.

While the impregnated-paper method affords a simple and valid technique for assessing the approximate susceptibility of strains of a species to an insecticide it is clear that the resistance factor determined from the LC_{50} could lead to wrong conclusions. The topical application of a known dosage gives more accurate results leading to firm conclusions. For indications of developing resistance the impregnated-paper method might be used, but if toxicological conclusions are to be valid then accurate dosages must be known.

Acknowledgments

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ADDITIONAL SYRPHIDAE FROM THE OLIVER AND OSOYOOS DISTRICTS OF BRITISH COLUMBIA

C. V. G. Morgan [1] and J. C. Arrand [2]

ABSTRACT

A list of 9 species of adult Syrphidae in 7 genera is presented with their hosts and month of catpure in 1969 in the vicinity of Oliver and Osoyoos in British Columbia.

Allan (1969) published a list of 39 species of adult Syrphidae collected in 1967 and 1968 mostly in southern areas of the Okanagan Valley of British Columbia. In 1969 he made further collections in the vicinty of Oliver and Osoyoos, but before he was able to summarize these he was forced to retire because of ill health. The 9 additional species collected by him in 1969 are listed in the accompanying table. These were identified by Dr. J. R. Vockeroth, Entomology Research Institute, Canada Department of Agriculture, Ottawa, Ontario.

[1] Contribution No. 319, Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2] British Columbia Department of Agriculture, Vernon, British Columbia.

Allan began these collections with the hope of finding species that, if reared in large numbers and released in orchards, would control aphids. However, except for some preliminary attempts to rear certain species, he was unable to proceed beyond collecting and sorting specimens.

Most of the 48 species in 23 genera collected by him in 1967, 1968, and 1969 are new records for the Okanagan Valley; 18 species and 6 genera are new records for British Columbia. In addition, 10 species remain unnamed. The number of new species collected in this one area of the Okanagan Valley illustrates our lack of knowledge of the Syrphidae of British Columbia.

Reference

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Syrphidae from the Oliver and Osoyoos districts of British Columbia, 1969

Species	Number of specimens collected	Place collected	Host	Date
Arctophila flagrans O.S.	1	Osoyoos	Unknown	August
Chrysotoxum sp.	6	Osoyoos	Unknown	June-Sept.
Epistrophe nitidicollis Mg.	1	Oliver	Mustard	May
Helophilus hybridus Lw.	1	Osoyoos	Unknown	June
Phalacrodira tarsata (Zett.)	1	Osoyoos	Dandelion	June
P. sp.	1	Oliver	Unknown	April
Toxomerus marginatus (Say)	25	Oliver	Mustard, garden flower	June-Aug.
T. occidentalis Cn.	11	Oliver, Osoyoos	Mustard, dandelion	June-July
Volucella bombylans (L.)	1	Osoyoos	Unknown	July

OBSERVATIONS ON *ERIOCAMPA OVATA* L. (HYMENOPTERA: TENTHREDINIDAE) INFESTING RED ALDER IN SOUTHWESTERN BRITISH COLUMBIA [1]

J. H. BORDEN AND W. F. DEAN [2]

Pestology Centre, Department of Biological Sciences,
Simon Fraser University, Burnaby, British Columbia

ABSTRACT

As in Quebec, **Eriocampa ovata** L. in British Columbia is bivoltine, parthenogenetic and overwinters as a prepupa. Unlike **E. ovata** in Quebec, the first instar larvae emerge on the lower side of the leaf, and pass through 6 or 7 rather than 5 or 6 larval instars. Defoliation characteristically leaves only the midrib and main secondary veins. In limited areas, small trees may be completely defoliated.

The red-backed sawfly, *Eriocampa ovata* L., introduced into Canada from Europe at an undetermined date, is now widespread on *Alnus* spp. throughout the country (Ross 1951; Raizenne 1957; Bouchard 1960). In British Columbia, one specimen was taken in Vancouver by Hopping and Leech on August 26, 1932 (J. W. E. Harris, pers. comm.). Although it is of little economic importance on either continent, it may severely defoliate young trees in eastern Canada (Bouchard 1960). Bouchard (1960) described the life history, morphology and characteristics of all the life stages of *E. ovata* on *Alnus rugosa* var. *americana* (L.) in Quebec.

In 1968, we observed *E. ovata* defoliating red alder *(Alnus rubra* Bong.) regeneration on Burnaby Mountain (elev. 1200 ft.), and have since noted similar defoliation in various locatilities in the lower mainland of this province. Our objectives were to note its habits, and its effect on *A. rubra*, with special attention to possible differences between the biology of *E. ovata* in eastern Canada and British Columbia.

As in Quebec (Bouchard 1960), *E. ovata* appears to be bivoltine in B.C. Adults, first observed on May 7 and 6 in 1969 and 1970, respectively, were continually present until the end of August, but were most numerous from mid May to early June, and from late June through July. Moreover, 16 adults emerged in rearing from June 30 to September 4. No males were collected or reared.

In the laboratory, 3 adults displayed a characteristic oviposition behaviour similar to that described by Bridgeman (1878). After wandering over the upper surface of a leaf and following its perimeter for some distance, the insect approached the central axis of the leaf, facing the petiole, and felt for the mid rib with the tip of its abdomen. It placed the ovipositor one to 2 mm from the mid rib, cut through the surface at an angle toward the main leaf vein, straightened its abdomen, inserted an egg deep into the mid rib, and withdrew the ovipositor. The entire process took 150 ±45 sec. (mean of 10 ovipositions by 3 females). It then moved forward and repeated the process, laying the next egg very near to or touching the preceeding one.

The oviposition scars are externally evident (Fig. 1). Internally, the eggs lie inside the vein, the cephalic pole facing ventrally and towards the leaf tip (Fig. 2). Eggs were rarely found in secondary veins, but in the laboratory, adults offered a limited number of leaves frequently oviposted into secondary veins once sites on the mid rib were taken. In 50 field-collected, infested leaves, there was a mean of 9.02 eggs per leaf (range, 1 to 25) and 3.67 per clutch (range, 1 to 10). The earliest field record of eggs was May 12 in both 1969 and 1970, and for larvae, May 15, 1969, but not until June 10, 1970 (following a period of unseasonally cool weather. Two eggs in the laboratory hatched in 10 and 11 days at 24 C.

Bouchard (1960) observed that first instar larvae on *A. rugosa* var. *americana* were impeded from leaving the incubation site by sclerotized leaf tissue. However, on *A. rubra* they easily chewed through and ingested the lower epidermis of the leaf, and unlike *E. ovata* in Quebec (Bouchard 1960) began to feed on the lower rather than the upper surface of the leaf.

All larval instars except the last are covered by a white, woolly, epidermal secretion (Fig. 3). Of fourteen larvae successfully reared individually, 9 passed through 6 larval instars over an average period of 18.2 days (range, 14 to 22 days) and 5 had 7 larval instars over 21.4 days (range 17 to 25 days). In Quebec *E. ovata* has 5 or 6 larval instars (Bouchard 1960).

Damage caused by *E. ovata* feeding was often extreme on young alder seedlings and saplings.

[1] Supported by an operating grant from the National Research Council of Canada.

[2] Associate Professor and Insect Rearing Technician, respectively.

Fig. 1. **E. ovata** oviposition scars on upper surface of red alder leaf. One scar designated by arrow.
Fig. 2 **E. ovata** eggs inside mid rib of red alder leaf as viewed from above.
Fig. 3 Feeding **E. ovata** larva skeletonizing leaf in characteristic manner.
Fig. 4 Alder sapling defoliated by **E. ovata** except for current year's apical growth.
Fig. 5 Leaves from defoliated red alder skeletonized by **E. ovata.**

However, the current year's apical growth was usually untouched (Fig. 4). Even after larvae have left the tree, the white exuviae on the branches implicate *E. ovata* as the principal defoliator. The alder sawfly, *Hemichroa crocea* (Fourc.) was not available for comparison, but defoliation by *E. ovata* can easily be separated from that by two chrysomelid beetles, *Pyrrhalta punctipennis* (Mannerheim) and the alder flea beetle, *Altica ambiens* (LeConte). The beetles chew holes in a leaf, at first leaving even the thinnest veins intact, while *E. ovata* consumes the fine veins (Fig. 3) and often so completely skeletonizes a leaf that only the mid rib and main secondary veins remain (Fig. 5).

A few late instar larvae were found in the field as late as October 18, 1969. The last instar larva drops without feeding from the tree on the same day as the final moult, and burrows into the soil where it forms a cocoon within 5 cm from the surface. Dissection of 30 cocoons throughout the winter disclosed only prepupae until the first 2 weeks of May when further development became evident.

We found no parasites or evidence of parasitism throughout the study.

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RESPIRATION AND CIRCULATION

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The fifth in a series prepared for specialists, this large, heavy book is a stupendous work of organization and system, indexing and filing, a *Handbuch* in the German tradition, of Teutonic thoroughness. Of the 315 contributors and reviewers, 78 are from the U.S.A., 6 from the U.K., 4 from Canada, and the rest from 19 other countries.

The arrangement is in 11 sections. In order, these are: general principles; basic physical and chemical data; thorax and ventilation; airways and gas movement; blood gases; heart and pumping action; vascular system and blood distribution; capillaries and the exchange system; invertebrate respiration; invertebrate circulation; plant respiration and fluid movement. Although the emphasis is thus on man and other vertebrates, the book will be important to anyone in active research on invertebrates and even plants, in the appropriate disciplines. It offers perhaps the swiftest and most effortless means of acquiring background, comparing fresh with previous work, avoiding duplication and entering the contemporary and established literature. To judge by a sample count on 400 pages there must be close to 6,000 references.

There are 232 tables, some of them enormous, e.g. Table 229, Translocation of growth regulators and herbicides in vascular plants; this is 49 pp. long and includes 369 references for 582 items. Some other tables of direct interest to entomologists concern: inhibition of 0_2 consumption; comparative anatomy of circulatory systems; electrical and mechanical properties of cardiac muscle; heart rates; hemolymph volumes; hemocytes; and carbohydrates in hemolymph. The names of the contributors are shown with the tables. Insects are well represented and the information is easily accessible even where it is embedded in large tables, by using the 83-page index and two mirror-image appendixes of 20 pages each, with matching common and scientific names. It is a pleasure to draw attention to this vast accumulation of organized and accessible data, the value and veracity of which is attested by the names of the distinguished compilers, contributors and authors.

A copy is available in the society's library, by courtesy of the Federation of American Societies for Experimental Biology, to whom we are grateful.

H. R. MacCarthy

NATIVE HOSTS OF WESTERN CHERRY FRUIT FLY *(DIPTERA: TEPHRITIDAE)* IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA

F. L. Banham[1]

ABSTRACT

In the Okanagan Valley, bitter cherry, **Prunus emarginata** Dougl., the principal host of the western cherry fruit fly, **Rhagoletis indifferens** Curran, was found at 3 locations only but may occur elsewhere in the Okanagan Valley in restricted habitats. The rare occurrence and unreliable fruiting habit indicate its existence is marginal. Adult **R. indifferens** were trapped on this host even though no fruit was present. This indicates that bitter cherry and probably, the less preferred native host, western choke cherry, **P. virginiana** var **demissa** (Nutt.) Torr., are both important to the ecology of isolated, low, endemic populations of **R. indifferens** in the central and possibly northern Okanagan Valley. No instances were found where endemic populations of **R. indifferens** on native hosts might have formed a host strain adapted to the earlier maturing, introduced, cultivated cherries. Widespread infestations of this pest have adapted to development on cultivated sweet and semi-sweet cherries and appear to be a recently introduced race that is distinct from the endemic populations on native hosts. **R. indifferens** on cultivated cherries had an earlier emergence peak that those on the native hosts and were not associated with the presence of bitter cherry.

INTRODUCTION

The western cherry fruit fly, *Rhagoletis indifferens* Curran, was first recorded in the Okanagan Valley in 1968 (Madsen, 1970). In 1969 and 1970, widely dispersed infestations were reported from Vernon in the north to Okanagan Falls about 66 miles south (Anon. 1969, 1970). None has been found in the Oliver-Osoyoos area at the southern end of the valley or immediately west in the Similkameen Valley.

In 1930, S. C. Jones recorded bitter cherry, *Prunus emarginata* Dougl. as a native host of *R. indifferens* in Oregon (Blanc and Keifer, 1955). In California, Blanc and Keifer traced adults from cultivated cherries to bitter cherry and believed the flies infesting cherry orchards originated from the native host. Frick *et al.* (1954), in Washington, showed that western choke cherry, *Prunus virginiana* var. *demissa* (Nutt.) Torr., was also a native host of *R. indifferens* but was less important than bitter cherry. According to Blanc and Keifer, the distribution of *R. indifferens* ranges from California into British Columbia and coincides with the distribution of bitter cherry. Bush (1966) defined the distribution of *R. indifferens* as ranging from north-central California to south-eastern British Columbia. Both descriptions of the distribution indicated it does not extend so far south or north as the extremes of distribution of bitter cherry.

Peters and Arrand (1968), stressed the importance of bitter cherry as a host reservoir from which *R. indifferens* could reinfest cultivated cherries in the Kootenay Valley of British Columbia. Madsen (1970), conducted a cursory survey in the Okanagan Valley in 1969, for the occurrence of native host plants but encountered only western choke cherry. A more intensive search for both hosts was conducted in 1970. The results of this survey and discussion of the ecological relationships between *R. indifferens* and the native and cultivated hosts in the Okanagan Valley are presented here.

MATERIALS AND METHODS

A search for bitter cherry in the Okanagan Valley was conducted in April and May, 1970 in all locations known or suspected to have favorable habitats similar to those described by Lyons (1954) and Hosie (1969). An intensive search for this host was also made in the Okanagan Mission and Westbank areas near cultivated cherry plantings where crop damage was caused by *R. indifferens* in 1968 and 1969. Vigorous stands of choke cherry at 3 widely separated sites with no bitter cherry nearby, were sampled for *R. indifferens* as possible alternate hosts. These were at Lambly Creek, 6 miles north of Westbank, adjacent to an abandoned sweet cherry orchard; at the Research Station, Summerland, about 1/3-mile from sweet cherries; and at the Upper Bench, Penticton, adjacent to a block of sweet cherries.

Bitter cherry was found at 3 sites in the

[1] Contribution No. 320. Research Station, Canada Department of Agriculture, Summerland, British Columbia.

Okanagan Valley. These were: at Deeper Creek, 6 miles south of Okanagan Mission; at Caesars, 1 mile south of Nahun; and at Ewing, 2.5 miles north of Fintry. All sites were within 1/4-mile of the shoreline of Okanagan Lake. The largest stand at Caesars was scattered over an area of about 2.5 acres and the smallest at Deeper Creek consisted of 18 large trees and numerous seedlings. Unsprayed, cultivated sweet cherries were located 1/2- and 1/4-mile from these stands.

Host plants at all sites were sampled for adults by trapping with sticky boards similar to those described by Kaloostian and Yeomans (1944). These were made from ¼-inch plywood 5½ x 11½ inches painted yellow on one face and covered with Stikem (polymerized butene, methylpropene and butane 97%; inert ingredients, 3%. Michel and Pelton Co., 5743 Landregan Street, Emeryville, California, 94608, U.S.A.). At each site, 5 to 12 traps were hung on branches of trees 4 to 8 feet above the ground. These were changed at about 14-day intervals. Two glycine-lye bait pans, described by Barnes and Madsen (1963), were set-out at one of these sites and 10 at another. Each 6-inch diameter bait pan was made from a 1-gallon plastic bleach container filled with 8 oz of glycine-lye mixture and suspended in a tree as described by Peters and Arrand (1968). Both types of trap were set-out commencing May 27, and inspected at 7- to 14-day intervals until September 24. The bait pans were serviced at each inspection by removing all trapped insects and other debris and either replacing the glycine-lye mixture or adding water to replace that evaporated from the original volume. Most identifications of *R. indifferens* on sticky board traps were made in the field with or without the aid of a hand lens. Specimens trapped in bait pans were identified in the field but when too many were present these were collected by straining the solution and taking them to the laboratory for identification. Adults were identified by wing patterns as illustrated by Bush (1966). The mature fruit of native host plants was also sampled and examined for larvae. If available, samples of not less than 5 lb of fruit were collected at each site. These were placed over 4-mesh wire screen for 21 days at room temperature to permit larvae infesting the fruit to mature and be extracted.

RESULTS

P. emarginata was found growing in association with the following trees and shrubs: Douglas fir, *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco; black cottonwood, *Populus trichocarpa* Torr. and Gray; Pacific willow, *Salix lasiandra* Benth.; mountain or thinleaf alder, *Alnus tenuifolia* Nutt.; water birch, *Betula occidentalis* Hook.; western red cedar, *Thuja plicata* Donn.; Douglas maple, *Acer glabrum* Torr. var *douglasii* (Hook.) Dipp.; and western choke cherry, *Prunus virginiana* var. *demissa* (Nutt.) Torr.

At all sites the peak of bitter cherry bloom was about May 5, similar to that of most cultivated varieties of sweet cherries. Following fruit set, there was a heavy June drop and a further heavy drop in the latter half of July. By August 5, no fruit remained on the trees at any site and all showed symptoms of stress from the hot, dry conditions.

Surveys conducted in Okanagan Mission and Westbank near cultivated sweet and semi-sweet cherry plantings where crops had been damaged by *R. indifferens* in 1968 and 1969, showed that choke cherry was abundant, particularly near Okanagan Mission. No bitter cherry was found; the closest known stand was at Deeper Creek, about 6 miles from two Okanagan Mission cherry orchards where damage was found. High hills separated these commercial blocks of cherries from the Deeper Creek site.

No bitter cherry was found during limited surveys in the Oliver-Osoyoos areas of the southern Okanagan Valley or in the adjacent Similkameen Valley. Bitter cherry was found at Armstrong, immediately north of the Okanagan Valley and was common at Salmon Arm, a further 20 miles north. Heavy crops of fruit matured at both locations.

Two adult *R. indifferens* were taken on sticky board traps at Ewing during the periods July 24 to August 5 and August 14 to 20, respectively. None was taken at Deeper Creek or Caesars on sticky board traps or in bait pans. Late season examination of bitter cherry fruit from Armstrong and Salmon Arm revealed abundant evidence of recent larval feeding damage including the presence of breather holes cut through the skin but all larvae had matured and left the fruit. *R. indifferens* adults have been found at Salmon Arm (Anon., 1969) and there have been unconfirmed reports of sporadic damage in cultivated cherries.

Western choke cherry is abundant and widespread in the Okanagan and Similkameen valleys and in the Armstrong and Salmon Arm districts. Heavy crops of fruit were observed in all areas. Black choke cherry, *P. virginiana* var. *melanocarpa* (A. Nels.) Sarg., is also abundant and widespread in the two latter areas. During the surveys, no evidence of larval feeding damage was found in mature fruit of either species. Western choke cherry was found wherever bitter cherry was recorded in the Okanagan Valley. No adult *R. indifferens* were taken on sticky board traps in stands of choke cherry at any of the 3 principal sites

sampled nor were any larvae extracted from fruit collected at these sites.

DISCUSSION

This study has established that bitter cherry is present in the Okanagan Valley but it occurs only in widely separated, restricted habitats. None of the stands was over 2.5 acres and all were within 1/4-mile of Okanagan Lake. Based on site studies at the 3 locations discovered, it is most likely to occur in protected areas with higher than normal humidity and soil moisture as are found in gullies and near streams. This and the fact that the plants suffered heat and moisture stress during the unusually hot, dry summer of 1970, resulting in a complete, premature fruit drop, confirms that the central Okanagan Valley is marginal to the greater distribution of this species (Lyons, 1954). None was found nor is likely to be found in the southern end of the valley or in the adjoining Similkameen Valley where summer conditions are even hotter and drier than those in the central areas where bitter cherry was found. The climate is more moderate at the north end of the Okanagan Valley, particularly at the north-west end of Okanagan Lake so that other bitter cherry sites may well be present.

The trapping of 2 adults in a stand of bitter cherry at Ewing, shows that this host plant is a factor in the ecology of isolated, low, endemic populations of *R. indifferens* in the central and possibly, northern Okanagan Valley. Trap catches were probably reduced by the lack of fruit to attract emerged adults and stimulate feeding, mating and oviposition. The presence of fruit on bitter cherry attracted adult *R. indifferens* at Creston, British Columbia, in 1970. Fly catches on sticky board traps were correlated directly with the presence or absence of fruit.

For endemic populations of *R. indifferens* to exist when bitter cherry produces no fruit, newly emerged females must seek cultivated cherry or the secondary native host, choke cherry, although no adults were taken on sticky board traps hung in this host nor were any larvae collected from fruit that was at a suitable stage of maturity for oviposition and larval development. Cultivated cherry is restricted to irrigated areas and annually produces light to heavy crops depending on spring frosts, whereas choke cherry is abundant, widespread and annually produces fruit. Two adult *R. indifferens* were taken on bitter cherry at Ewing, July 24 to August 5 and August 14 to 20. These dates are much later than the emergence peak of June 9 to 26, for this species in cultivated sweet and semi-sweet cherries and after crop harvesting. Choke cherry with abundant, immature fruit at these dates may enable *R. indifferens* to survive when fruit of the principal native host is not available.

The rare occurrence of bitter cherry, apparently restricted to the central and possibly, northern Okanagan Valley, is unlikely to have influenced the rapid spread of *R. indifferens* in cultivated cherry plantings throughout most of the valley. Widespread infestations of this insect on cultivated cherries probably did not evolve from populations on bitter cherry in these areas. This is supported by lack of evidence to indicate that the endemic populations of *R. indifferens* on native hosts have formed a host strain adapted to development in fruits of the introduced, earlier maturing, cultivated host. No adults were trapped in 2 unsprayed, cultivated cherry plantings located 1/4- and 1/2-mile from stands of bitter cherry and both owners reported no infested fruit had ever been found. In addition, no other plantings of cultivated cherries up to 6 miles from bitter cherry have been infested with *R. indifferens* to indicate the possibility that a shift to the introduced host had occurred. These results are in contrast with those of Simkover (1953), who reported that in the laboratory *R. indifferens* exhibit a preference for cultivated cherries over the principal native host and with those of Bush (1966) who reported that a continual shift occurs from the native to the cultivated host in cherry growing areas of northern California. Both indicate the occurrence of adaption from the native to the introduced host. It is concluded that isolated, endemic populations of *R. indifferens* occur principally on bitter cherry and occasionally on choke cherry at such low levels that adaption to the cultivated host is unlikely in the Okanagan Valley.

The marginal existence of bitter cherry with occasional or frequent crop failures and the resulting necessity to depend on the less suitable choke cherry may explain why *R. indifferens* was not a pest in the Okanagan Valley before 1968. The sudden widespread occurrence of this pest in cultivated cherry plantings here may be similar to that in Montana. There, *R. indifferens* occurs in cherry growing areas beyond the range of bitter cherry and according to Bush (1966), is a recent introduction. Thus, in the Okanagan Valley, there may be 2 distinct host races of *R. indifferens;* an isolated, low, endemic race on the native hosts and a widespread, recently introduced race on cultivated sweet and semi-sweet cherries. Elsewhere, the rapid spread of this pest in commercial cherry plantings has occurred mainly in areas where bitter cherry is abundant. Recent examples include the Kootenay Valley of British Columbia (Arrand and Peters, 1968), the Yakima Valley, (Eide *et al.*, 1949) and the Wenatchee area (Frick *et al.*, 1954) of Washington.

In the Okanagan Valley, *R. indifferens* infesting

irrigated commercial cherries has a greater tolerance to summer temperature extremes than its principal native host. Irrigation, besides supporting the introduced host, may be essential for survival of the insect under these conditions. Bush (1966) reported that *Rhagoletis* species appear to be less tolerant of dry conditions than their hosts. The apparent lack of bitter cherry in the Oliver-Osoyoos areas at the southern end of the Okanagan Valley and in the adjacent Similkameen Valley is unlikely to prevent the eventual establishment of this pest in these areas.

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Mr. T. B. Lott, Plant Pathologist (retired), Summerland, B.C. identified plant species and helped locate stands of bitter cherry in the Okanagan Valley. This invaluable assistance is gratefully acknowledged.

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Delete "The skunk was . . . three days" and insert: The skunk was placed in an outdoor cage, in a site known to be suitable for development of *D. andersoni*, and was infested with about 8000 larvae on 9 July 1968. No development of larvae was noted and no nymphs appeared. Later the skunk was caged over water and infested with about 6000 larvae on 10 September 1968. No fed larvae were seen on the skunk or in the water tray during the next three days.

OCCURRENCE OF PHYTOSEIID MITES *(ACARINA: PHYTOSEIIDAE)* IN APPLE ORCHARDS IN SOUTH CENTRAL BRITISH COLUMBIA

R. S. DOWNING AND T. K. MOILLIET[1]

ABSTRACT

Sprayed and nonsprayed apple trees in the interior of British Columbia were sampled from 1967-70 for mites belonging to the family Phytoseiidae. **Typhlodromus occidentalis** Nesbitt and **T. columbiensis** Chant were the only species commonly found in sprayed orchards. **T. occidentalis** was more abundant. In nonsprayed orchards, **T. caudiglans** Schuster was practically the only phytoseiid found in the Okanagan and Similkameen valleys whereas it and **Phytoseius macropilis** (Banks) were the most common mites found in samples from higher rainfall districts bordering the Shuswap and Arrow Lakes. **T. pyri** Scheuten was less widely distributed than the above mites but was found in large numbers on nonsprayed trees in the Shuswap area and at Summerland in a dwarf apple orchard that is irrigated by overhead sprinklers. Five other species of phytoseiids were found but in very small numbers.

INTRODUCTION

During the past 2 or 3 years, predaceous mites belonging to the family Phytoseiidae have become important to the British Columbia fruit industry. These mites have controlled some species of phytophagous mites better and much more cheaply than acaricides. In 1968, a publication (Downing and Arrand 1968) outlining the procedures of integrated control including information on habits, recognition and conservation of phytoseiids, was made available to orchardists. Since then many British Columbia fruitgrowers, with the help of the provincial Department of Agriculture, have become familiar with the use of predaceous mites in apple pest control programs. During this time the population density of the phytoseiids increased to such an extent that many growers were able to omit most acaricidal sprays that were usually required.

Other apple growing areas of the world are having similar success with phytoseiid mites but often different species are involved. For example, in Missouri apple orchards, *Neoseiulus (=Amblyseius) fallacis* (Garman) and *Galendromus (=Typhlodromus) longipilis* (Nesbitt) according to Poe and Enns (1969) are the most important phytoseiids. *Typhlodromus occidentalis* Nesbitt (Hoyt 1969) is the predominant species in the State of Washington U.S.A. whereas in England *Typhlodromus pyri* Scheuten (Collyer 1964) is the most important phytoseiid.

Anderson *et al.* (1958) listed a total of 28 species of phytoseiids in British Columbia. Fourteen were found in orchards but only 3 occurred in relatively large numbers: *Typhlodromus occidentalis* Nesbitt, *T. caudiglans* Schuster (referred to as *T. rhenanus* by Anderson *et al.*) and *Phytoseius macropilis* (Banks). At this time, phytoseiid mites could not survive in sprayed orchards. Consequently their numbers were not sufficient to suppress populations of phytophagous mites. Now the situation has changed. This report describes the current status of phytoseiids in apple orchards in south central British Columbia.

METHODS

Most of the collections of phytoseiid mites were made from 1967-1970 in the dry Okanagan and Similkameen valleys (18-36 cm. annual precipitation) where the majority of apple orchards in British Columbia are located. Collections were also taken from locations with higher rainfall (50-100 cm. annual precipitation) such as the fruit growing areas near Shuswap, Arrow and Christina lakes. Samples were usually collected during the growing season when the majority of phytoseiids were on the leaves. When collections were made during the winter, spring or fall, overwintering sites such as twigs, bark, and sometimes duff at the base of the trees were sampled. Leaf samples were processed by the method of Henderson and McBurnie (1943) as modified by Morgan *et al.* (1955. Pieces of twig and bark were examined for mites under a binocular microscope. The duff samples were processed in a Berlese funnel using a glass plate collector. The perimeter of the plate was treated with a sticky substance to prevent the mites from escaping. Identification of the phytoseiid mites listed in this report was based on the generic concepts and keys of Chant (1957, 1959, 1965).

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[1] Contribution No. 310, Research Station, Summerland, British Columbia.

RESULTS AND DISCUSSIONS

Major Species

Five species of phytoseiids were generally the most abundant in the collections and under certain conditions could play a prominent part in the control of phytophagous mites.

Typhlodromus occidentalis Nesbitt. At present this is without doubt the most important predaceous phytoseiid in sprayed orchards. In Okanagan and Similkameen apple orchards where spray programs have been adjusted to allow its maximum survival, this predator has been the main factor in control of McDaniel spider mite, *Tetranychus mcdanieli* McG., which was previously the most feared of all phytophagous mites. *T. occidentalis* is not so effective against the European red mite, *Panonychus ulmi* (koch). However, if oil is applied to apple trees at the half-inch green bud stage to kill most of the red mite winter eggs, *T. occidentalis* will usually hold the surviving mites under control so that a summer acaricide is seldom necessary. This predator also feeds on and suppresses population growth of the apple rust mite, *Aculus schlechtendali* (Nalepa). However, the apple rust mite is an excellent alternate food source for *T. occidentalis* as it is present during late May and early June when the other two phytophagous mites are scarce.

T. occidentalis was found in all areas sampled except those with a very high rainfall. It was found in extremely small numbers in nonsprayed orchards presumably because of competition from other predators including different species of phytoseiids and its inability to survive on foods such as pollen (Laing 1959), when animal prey is not available. This species survives in sprayed orchards because it has developed strains with a high degree of tolerance to organic phosphate insecticides, such as azinphosmethyl, that are used for control of the codling moth, *Laspeyresia pomonella* (L).

The overwintering habits of *T. occidentalis* play a significant role in its survival. If its preferred prey, the McDaniel spider mite is present and wintering on the trunks of apple trees, *T. occidentalis* will also winter there and probably be protected from freezing by snow cover. If, on the other hand, the European red mite is the main prey, then *T. occidentalis* will spend the winter in the aerial parts of the tree on twigs etc. near red mite winter eggs. These locations offer little or no protection from cold weather. This was well demonstrated after the winter of 1968-69 when temperatures in the Okanagan Valley dropped to -25° C or lower. *T. occidentalis* suffered almost complete mortality where it wintered in the aerial parts whereas it survived with little mortality where it wintered on the trunks.

In apple orchards where integrated control is practised, European red mite and apple rust mite are generally present whereas the McDaniel spider mite is not. This is because *T. occidentalis* is highly efficient as a predator of the McDaniel spider mite but much less effective against the other two mites. In such orchards *T. occidentalis* therefore winters mainly in the aerial parts of the tree and consequently is subject to periodic kills by cold winters.

T. caudiglans Schuster is the most abundant and often the only phytoseiid in nonsprayed orchards in the Okanagan, Similkameen and Arrow Lake regions. It has been collected from all the areas sampled including the high rainfall area of Seymour Arm on Shuswap Lake.

T. caudiglans is much more tolerant of cold than *T. occidentalis*. Where the two mites wintered together in the aerial parts of apple trees during periods of -25° to -35° C there was almost 100% survival of *T. caudiglans* but almost 100% mortality of *T. occidentalis*. Live *T. caudiglans* were also collected from the North Thompson area after a winter during which a temperature of -43° C was recorded. This species, unlike *T. occidentalis*, survives during periods of low prey density because it is able to feed on pollen (Putman 1962). Probably the greatest weakness of this predator is its inability to survive the pesticides used in orchards. Unlike *T. occidentalis*, it is very susceptible to the organic phosphate insecticides that are used for codling moth control.

T. columbiensis Chant. Chant (1959) described this species from a specimen he collected in 1956 from wild cherry at Hedley, B.C. in the Similkameen Valley. Since then *T. columbiensis* has been found in most areas of the Okanagan and Similkameen valleys. It is present but less common in the Shuswap and Arrow lake districts. Very few specimens have appeared in samples from non-sprayed orchards. After the extremely cold winter of 1968-69 which severely reduced populations of *T. occidentalis*, large populations of *T. columbiensis* were found in some orchards. In some instances they comprised close to 50% of the phytoseiid population. However, in 1970 when *T. occidentalis* had recovered from the cold winter and was at a high population density, *T. columbiensis* accounted for only about 3% of the phytoseiids in those orchards. The apparent competition from *T. occidentalis* may explain the rise and fall of *T. columbiensis* populations. However, because this rise of *T. columbiensis* took place in sprayed orchards there is good reason to suspect that organophosphate resistant strains of this mite may be developing. Resistant strains would assist integrated control.

Laing (1969) and Lee and David (1968) showed

that *T. occidentalis* does not feed on pollen, leaves, or fungus spores as alternate food sources when prey mites are not available. Our experiments showed that *T. columbiensis* is able to survive and lay eggs when fed a diet of pollen and therefore should be able to survive during the early part of the growing season when numbers of prey mites are low.

Phytoseius macropilus (Banks). This was the most common phytoseiid collected in the Shuswap region where the annual precipitation is 50-65 cm. It was also found in the Arrow Lake district. It has not been taken in samples from sprayed orchards or from any orchard in the Okanagan or Similkameen valleys except from a nonsprayed orchard west of and 500 m. above Oliver.

T. pyri Scheuten. *T. pyri* is probably the best known and has the greatest world wide distribution of all members of the family Phytoseiidae. However, its distribution in the interior of British Columbia is very limited. It has been taken from nonsprayed apple trees near Christina Lake and in the Shuswap region, particularly around Sicamous and Mara Lake where it was the main species present. It, along with *T. caudiglans*, is the main mite predator in a dwarf apple orchard that is irrigated by overhead sprinklers at the Summerland Research Station. Perhaps overhead sprinkling is creating conditions similar to those in high rainfall areas where *T. pyri* is more common. If so, this predator may become more widespread, as overhead sprinkling becomes more widely practised. According to Collyer (1964), and from observations here, *T. pyri* is an effective predator. It could be very useful for control of phytophagous mites in British Columbia apple orchards if organic phosphate resistant strains of the mite could be developed.

Minor Species

The following five phytoseiids were found only in certain collections and in very limited numbers and do not appear very promising as predators in apple orchards.

T. soleiger (Ribaga) has been found only in nonsprayed orchards at Silverton, Christina Lake and at a high elevation (800 m.) in the Okanagan Valley.

T. arboreus Chant is very similar in appearance to *T. columbiensis* but has been found only once in a sample from a semi-neglected apple orchard in Summerland.

T. smithi Schuster was found on twigs from a nonsprayed apple tree near Vavenby.

Amblyseius cucumeris Oudemans is usually found on low growing plants including grape vines but was taken once from a leaf sample of apple trees in Kelowna.

A. fallacis (Garman) is one of the most important phytoseiids in the eastern United States and is able to survive in sprayed orchards in Missouri (Poe and Enns 1969). It is comparatively scarce in apple orchards of the interior of British Columbia but a few have been taken from semi-neglected apple trees in Summerland.

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THE PSYLLIDAE OF BRITISH COLUMBIA WITH A KEY TO SPECIES

R. L. KITCHING[1]

ABSTRACT

A list is presented of the 38 plant-lice or Psyllidae recorded from British Columbia. Keys to the species are given with locality records, together with an additional 28 species recorded from adjacent areas of Alberta, Washington and Alaska. The keys are adapted from those given in monographs by Crawford (1914), Caldwell (1938a) and Tuthill (1943) with the addition of ten species not included in their keys.

INTRODUCTION

The Psyllidae (=Chermidae) of British Columbia have been neglected as a group and no comprehensive check-list has been published since Downes' (1927) list which consisted of eight species only. Two monographs on the group for the whole of North America have been produced, namely those of Crawford (1914) and Tuthill (1943), but the latter work covered the sub-families Triozinae and Psyllinae only. Other writers, notably Klyver (1932b), Caldwell (1936, 1937, 1940), Strickland (1938, 1939) and Jensen (1956), have described species and published records of the occurrence of psyllids from British Columbia and adjacent areas and the list of Hemiptera of North America by Van Duzee (1917) also contains some records for the region. The list given below is based upon these works and upon the collection of the late W. Downes preserved in the Spencer Entomological Museum of the University of British Columbia and brought to my attention by Dr. G. G. E. Scudder.

CHECK-LIST OF THE PSYLLIDAE RECORDED FROM BRITISH COLUMBIA

In this list the nomenclature follows Crawford (1914) and Tuthill (1943) and, therefore, conflicts to some extent with that of Caldwell (1938a). I base this choice on what appears to be the most common modern usage both in North America and among European workers (eg. Kloet and Hincks, 1964). The reference following the author and date of each species gives the source of my record which is a published work except when drawn from the Downes' collection ('Downes coll.') or from the notes of Downes preserved with the collection ('Downes notes'). I have given the oldest reference I could find in each case although I do not claim that these are the earliest records of the occurrence of each species in the province.

Subfamily:	LIVIINAE	
Genus:	*Livia* Latreille	
Species:	*caricis* Crawford 1914	Crawford 1914
Genus:	*Aphalara* Förster	
Species:	[2]*calthae* (Linnaeus 1861)	Downes coll.
	rumicis Mally 1894	Klyver 1932b
	angustipennis Crawford 1911	Downes 1927
	veaziei Patch 1911	Downes coll.
	nebulosa kincaidi Ashmead 1910	Klyver 1932b
	vancouverensis Klyver 1932	Klyver 1932b
	[2]*persicaria* Caldwell 1937	Waddell 1952

[1] Institute of Animal Resource Ecology, University of British Columbia, Vancouver 8, Canada.

[2] **Calthae** is not accepted by Caldwell (1937) as a North American species and he has described several further species including **persicaria** from North American material previously ascribable to **calthae** (see keys and notes below).

Subfamily:	TRIOZINAE	
Genus:	*Trioza* Förster	
Species:	*maura* Förster 1848	Klyver 1932b
	quadripunctata Crawford 1910	Downes' notes
	albifrons Crawford 1910	Tuthill 1943
	frontalis Crawford 1910	Klyver 1932b
	inversa Tuthill 1939	Tuthill 1939
	varians Crawford 1910	Van Duzee 1917
	incerta Tuthill 1943	Tuthill 1943
	occidentalis Tuthill 1939	Tuthill 1939
	longicornis Crawford 1914	Crawford 1914
Subfamily:	PSYLLINAE	
Genus:	*Psylla* Geoffroy	
Species:	*alni* (Linnaeus 1758)	Downes 1927
	caudata Crawford 1914	Klyver 1932b
	galeaformis Patch 1911	Downes coll.
	floccosa Patch 1909	Downes coll.
	trimaculata Crawford 1914	Klyver 1932b
	striata Patch 1911	Tuthill 1943
	coryli Patch 1912	Tuthill 1943
	[3]*?stricklandi* (Caldwell 1939)	Downes' notes
	magnicauda Crawford 1914	Tuthill 1943
	buxi (Linnaeus 1758)	Downes coll.
	pyricola Förster 1848	Downing, Morgan & Proverbs 1956
	parallela Crawford 1914	Klyver 1932b
	minor Crawford 1914	Crawford 1914
	[3]*?latiforceps* Tuthill 1943	Downes' notes
Genus:	*Arytaina* Förster	
Species:	*fuscipennis* Crawford 1914	Crawford 1914
	robusta Crawford 1914	Tuthill 1943
	pubescens Crawford 1914	Downes coll.
	spartiophila (Förster 1848)	Downes 1957
Genus:	*Psyllopsis* Löw	
Species:	*fraxinicola* (Förster 1848)	Downes coll.
Genus:	*Euphyllura* Förster	
Species:	*arbuti* Schwartz 1904	Klyver 1932b
	arctostaphyli Schwartz 1904	Klyver 1932b

KEYS TO THE SPECIES OF PSYLLIDAE RECORDED FROM BRITISH COLUMBIA AND ADJACENT AREAS

The keys that follow include all the species listed above together with additional species recorded from Alberta, Washington State and Alaska south of the 63° N parallel. I include these because the list above cannot claim to be complete and species recorded from adjacent areas may well be found within the borders of the province. The keys are based upon those of Crawford (1914), Caldwell (1938a) and Tuthill (1943) suitably abridged and added to. I have added eight species of **Aphalara** and one of **Psylla** that were not included in these works although none of the nine is recorded yet from British Columbia. The keys to these additional species are based on the published descriptions and exact references are given. Except where otherwise stated, place names in parentheses represent records within British Columbia.

[3] These two species of **Psylla** are marked with a question mark in Downes' notes and I can locate no further records for them. I retain them as records needing confirmation.

KEY TO SUB-FAMILIES OF THE PSYLLIDAE (AFTER CRAWFORD 1914)

1. Frons not covered by genae; genae not produced into conical processes; front ocellus at extremity of frons. 2

—. Frons covered by genae; genae usually produced into conical processes ('genal cones'); front ocellus embedded between vertex and genae. 3

2. Vertex flat and horizontal, with frons beneath it in the form of a narrow (usually elongate) sclerite from clypeus to front ocellus; wings often more or less thickened and maculated. .... LIVIINAE

—. Vertex rounded downward in front, not horizontal, with frons as a distinct sclerite usually forming a uniformly smooth surface with vertex and genae; wings usually membranous............. PAUROPSYLLINAE

3. Basal tarsal segment of hind-legs without a pair of black claw-like spines at their tip; radius, media and cubitus usually diverging at same point from basal vein; wings usually angulate at apex.................. TRIOZINAE

—. Basal tarsal segment of hind-legs with two black claw-like spines at tip; the three veins not diverging at the same point from basal vein but media and cubitus with a common stem; wings rarely angulate at apex....... PSYLLINAE

One other sub-family of psyllids, the CARSIDARINAE, is recorded from North America but I have found no records for farther north than Ohio (Caldwell 1938a). This sub-family is distinguished from all others by having 'a head deeply cleft in front, with the antennae attached to the truncate anterior ends on each side of the cleft' (Crawford, 1914).

KEY TO GENERA OF THE LIVIINAE (AFTER CRAWFORD 1914)

1. Eyes greatly flattened, not hemispherical; vertex longer than broad; pronotum extending far down laterally toward coxae; wings thickened...................**Livia** Latreille

—. Eyes more or less hemispherical; vertex not longer than broad.........**Aphalara** Förster

KEY TO SPECIES OF THE LIVIINAE

Genus: **Livia**

Only one species of **Livia, caricis** Crawford, is recorded from the region and is characterised by Crawford as follows: 'length seldom more than 3mm., often less, vertex not deeply emarginate in front, scarcely raised on margins, flagellum of antennae usually about two and a half times as long as segment II; forceps of male usually short, stout, not pyriform, truncate at apex; wings not maculated, semi-transparent, thick and transversely wrinkled.'

(Glacier, Duncan, Riske Creek and Kamloops).

Genus: **Aphalara**

1. Clypeus much elongated, more or less cylindrical, rounded or truncate at apex extending down and forward.......**'calthae'** group..8
(Recorded as **calthae** L. from Quesnel, Stanley and Soda Creek).

—. Clypeus sub-globose or pyriform, not elongated, more or less adpressed to face.....2

2. Wings distinctly maculated or banded.......3

—. Wings not distinctly maculated or banded...7

3. Forceps of male clavate, with inwardly directed tooth or inner anterior margin, subapically...4

—. Forceps of male not clavate at apex, without inner subapical tooth.....................6

4. Wings clear with an irregular brown band running diagonally across their apices; colour of body reddish to flavous...**rumicis** Mally
(Chilliwack).

—. Wings opaque, whitish, covered more or less densely with brown spots.................5

5. Wing spots running together to form maculae, more numerous distally; general colour grey with yellowish or brownish tinge on head and thorax and dark transverse stripes on dorsum of abdomen.........**vancouverensis** Klyver
(Recorded and described from Duncan).

—. Wing spots small, round; general colour greenish yellow with whitish stripes on dorsum of thorax..........**angustipennis** Crawford
(Vernon, Quesnel and Soda Creek).

6. Posterior process of male anal valve tapering uniformly to apex, not lanceolate; forceps deeply bifurcate with two long, thin processes; antennae one and a half times as long as head width ....**alaskensis** Ashmead
(Recorded from Fox Point, Alaska and Easton, Washington (Crawford 1914)).

—. Posterior process of male anal valve conspicuously lanceolate, petiolate at base; forceps T-shaped; antennae $1\frac{1}{4}$ times head width.
...............**nebulosa kincaidi** Ashmead
(Chilliwack and Triangle Island).

7. Forceps of male with caudal margins appearing straight or slightly concave; dorsal valve of female genital segment relatively straight with rather abruptly upturned apex; antennae varying in length, at least as long as head width......................**veaziei** Patch
(Victoria, Quesnel and Prince George).

—. Forceps of male with caudal margins distinctly sinuate or convex in lateral aspects; female genital segment with dorsal valve sinuate or, if appearing straight, apex not upturned; antennae almost twice as long as head width.
.........................**fumida** Caldwell
(Recorded by Strickland (1939) from several localities in Alberta).

[4]8. Body entirely black. .**manitobaensis** Caldwell
(Recorded by Strickland (1939) from Wabumun, Alberta).

—. Body orange to red but not entirely black 9

9. Fore-wings not hyaline often with dark areas, bands or spots 10

—. Fore-wings hyaline......................11

10. Fore-wings with a sub-apical brown band and spot on the commissural margin; membrane yellowish.................**dentata** Caldwell

[4] The key to this and the following six species of **Aphalara** is constructed from Caldwell's original descriptions (1937, 1938b) of the species previously designated as **calthae.** I was restricted, therefore, to the characters included in his descriptions. The four species, **confusa, simila, persicaria** and **loca,** will be found difficult to separate, especially the females, and this should not be attempted without Caldwell's (1937) diagrams of the genitalia to hand (e.g. the females of **confusa** and **simila** are separated on the length of the proboscis-like extension of their dorsal valves).

(Records from Medicine Hat, Alberta in Strickland (1938)).

—. Fore-wings with no bands or spots, terminations of all veins usually have surrounding dark areas, sub-apical faint brown cloud may be present. . . . . **curta** Caldwell
(Recorded by Strickland (1938) from Beaverlodge, Alberta).

11. Males. 12
—. Females. 15
12. Forceps of genitalia having relatively long anterior-mesal processes widely separated at their tips from the apices of the forceps 13
—. Anterior-mesal processes of forceps relatively short and not widely separated from the apices of the forceps at their tips. 14
13. Tips of forceps squarely truncate. . . . . **confusa** Caldwell
(Recorded from several localities in Alberta by Strickland (1938)).
—. Tips of forceps tapering and rounded. . . . . **loca** Caldwell
(Recorded from several localities in Alberta by Strickland (1938)).
14. Anterior-mesal processes short and closely adpressed to bodies of forceps with tip not quite reaching apices of forceps, forcep tip more or less square. . . . . **persicaria** Caldwell
(Creston).
—. Anterior-mesal processes short but not closely adpressed to bodies of forceps, forcep tip oblique. **simila** Caldwell
(Recorded by Strickland (1938) from Wabamun, Alberta).
15. Dorsal valve of genitalia with a proboscis-like, downward pointing extension, circum-anal ring of even width all round. 16
—. Dorsal valve with no proboscis-like extension: circum-anal ring with an apron-like distal extension. 17
16. Head greatly deflexed. . . . . . **confusa** Caldwell
—. Head not greatly deflexed . . . . **simila** Caldwell
17. Dorsum of dorsal valve sinuate beyond anal opening, apex of this valve narrowing to a nose-like apex; anal vein finely serrate. . . . . **persicaria** Caldwell
—. No nose-like apex to the dorsal valve; anal vein not finely serrate. . . . . **loca** Caldwell

A further species, **Aphalara hebecephala**, described by Caldwell in 1936 is recorded by Strickland from Alberta but I found Caldwell's description too incomplete to include the species in this key.

One final word on the '**calthae** group' and that is that if Caldwell's supposition holds, that the North American '**calthae**' are, in fact, several closely related species, then we may expect that more species will be described and determination to a particular species at this stage must be made with circumspection which will be removed only after further work on the group.

THE PAUROPSYLLINAE

Only one species of this sub-family, namely **Calophya triozomima** Schwartz, is recorded from the region, by Strickland (1939) from Medicine Hat, Alberta. Crawford (1914) characterises the species as follows: 'genal cones not longer than broad, usually much reduced; wings more or less angulate at apex, hyaline, transparent, shining, pterostigma short and small; prescutum long'.

KEY TO GENERA OF THE TRIOZINAE (AFTER TUTHILL 1943)

1. Radius, media and cubitus arising from basal vein at same point. 2
—. Radius, media and cubitus not arising at same point, radius and media or media and cubitus with a short, common petiole. . . . . **Hemitrioza** Crawford
2. Genae produced as usually conical processes at least moderately long (usually half as long as vertex or longer). . . . . **Trioza** Főrster
—. Genal processes, if present, very short, conical or pad-like, sometimes lacking, or genae smoothly, spherically swollen. . . . . **Paratrioza** Crawford

KEY TO SPECIES OF THE TRIOZINAE (AFTER TUTHILL 1943)

Genus: **Trioza**

1. Hind tibiae with two inner apical spines. 2
—. Hind tibiae with three inner apical spines. . . . 9
2. Genal processes longer than vertex . . . . **pulla** Tuthill
(Recorded by Tuthill (1943) from Washington).
—. Genal processes not longer than vertex (usually distinctly shorter). 3
3. Antennae at least twice as long as width of head. . . . . **longicornis** Crawford
(Vancouver)
—. Antennae less than twice as long as width of head (rarely over 1¾ times as long). 4
4. Marginal cells of fore-wings very small; female genital segment over half as long as rest of abdomen. 5
—. Marginal cells typical size for **Trioza**; female genital segment less than half as long as rest of abdomen. 6
5. Dorsal valve of female genital segment straight and acute apically; length about 4 mm. . . . . **occidentalis** Tuthill
(Recorded and described from Kaslo Creek).
—. Dorsal valve of female genital segment upturned and blunt apically; length about 3.5 mm. . . . . **rubicola** Tuthill

(Described by Tuthill (1943) from Tacoma, Washington).

6. Antennae $1\frac{1}{2}$ times as long as width of head. 7
—. Antennae at least $1\frac{3}{4}$ times width of head ....**varians** Crawford
(From British Columbia (Van Duzee, 1917)).
7. General colour black; female genital segment straight and acute. ....**incerta** Tuthill
(From British Columbia (Tuthill, 1943)).
—. General colour green to orange, head often black; female genital segment shorter, strongly curved ventrally. 8
8. Vertex strongly bulging anteriorly; caudal lobes of male proctiger short, only half as long as axial portion ....**minuta** Crawford
(Recorded by Strickland (1938) from several localities in Alberta and by Tuthill (1943) from Washington).
—. Vertex not strongly bulging; caudal lobes of male proctiger as long as axial portion. ....**maura** Főrster
(Thormanby Island).
9. Thorax very strongly arched; male proctiger arcuate caudally but not produced into an extended lobe; both valves of female genital segment straight, about equal in length, ventral valve not upcurved to meet dorsal valve. ...10
—. Thorax moderately arched; male proctiger with a prominent caudal lobe (either apical or basal); female genital segment with at least the ventral valve strongly upcurved. 11
10. Fore-wings with four dark spots on posterior margin..........**quadripunctata** Crawford
(Quesnel and Soda Creek).
—. Fore-wings immaculate. ..**albifrons** Crawford
(From British Columbia (Tuthill, 1943)).
11. Male proctiger with caudal lobes as long as axial portion, lobe never entirely basal; antennae $1\frac{1}{2}$ or more than $1\frac{1}{2}$ times as long as width of head. 12
—. Caudal lobe of male proctiger much shorter than axial portion, lobe basal in origin; antennae 1 1/3 times as long as width of head. ....**inversa** Tuthill
(From British Columbia (Tuthill, 1943)).
12. Forceps of male in lateral view parallel sided, not enlarged apically; species about 3 mm. in length; colour typically orange with black tarsi and antennae but may be much darker with brown markings..........**sulcata** Crawford
(Recorded by Strickland (1938) from Edmonton, Alberta).
—. Forceps of male in lateral view slender basally, enlarged apically; species about 3.5 mm. in length; colour orange-red to brown with darker antennae, genal processes and abdomen. ....**frontalis** Crawford
(Victoria).

Genus: **Paratrioza**

A single species of this genus, **cockerelli** (Sulc) is recorded from the region, from several localities in Alberta by Strickland (1938, 1939). The species is characterised by Tuthill (1943) as follows: 'a small (3 mm. to tip of folded wings) species with hyaline fore-wings and having genae produced as small but distinct conical processes'.

Genus: **Hemitrioza**

Again a single species of this genus, **washingtonia** Klyver, is recorded from the area. The species was described from a single individual from Toppenish, Washington by Klyver (1932b). Tuthill (1943) characterised it as follow: 'species with costal margins of fore-wings not strongly arched, Rs long, straight, extending beyond furcation of media; general colour brown, forewings immaculate'.

KEY TO GENERA OF THE PSYLLINAE (AFTER TUTHILL 1943)

1. Genal processes large, flattened, contiguous, on same plane as vertex; fore-wings thickened, rugose, rhomboidal. ....**Euphyllura** Főrster
—. Genal processes not flattened, rarely contiguous; fore-wings usually membranous, sometimes thickened and rugose but not rhomboidal. 2
2. Pleural suture of prothorax extending to middle of lateral margin of pronotum, propleurites equal dorsally. 3
—. Pleural suture of prothorax oblique, propleurites not equal dorsally. ....**Psylla** Geoffroy
3. Genal processes sharply depressed from plane of vertex parallel to it ....**Arytaina** Főrster
—. Genal processes not depressed from plane of vertex....................**Psyllopsis** Löw

KEY TO SPECIES OF THE PSYLLINAE (MODIFIED FROM TUTHILL 1943)

Genus: **Psylla**

1. Eyes borne on prominent stalk-like portion of the head ....**negudinis** Mally
(Recorded by Strickland (1938) from Edmonton, Alberta).
—. Eyes not borne on prominent stalk-like portion. 2
2. Antennae twice as long as width of head or longer. 3
—. Antennae distinctly less than twice as long as width of head 8
3. Smaller (up to 3.5 mm. to tip of folded wings) species; yellowish green wings, not clear or hyaline; distal third of antennae dark, segments without dark annuli..**striata** Patch
(From British Columbia (Tuthill, 1943)).
—. Larger (more than 4.5 mm. to tip of folded

wings) species; without above combination of characters. 4
4. Pterostigma present, prominent. 5
—. Pterostigma obsolete or nearly obsolete. 7
5. Genal processes no longer than basal width, typically rounded apically. . . **alni** (Linnaeus) (Sooke and Victoria).
—. Genal processes longer than basal width, sharper apically. 6
6. Female genital segment 3/4 as long as rest of body; male forceps enlarged apically. . . . . **caudata** Crawford (Vancouver (Klyver, 1932b)).
—. Female genital segment not over 1/2 as long as rest of body; male forceps nearly parallel, margined to apices. . . . . **galeaformis** Patch (Quesnel and Soda Creek).
7. Female genital segment larger than rest of abdomen, slender, styliform, abruptly enlarged basally; male forceps not notched apically. . . . . **floccosa** Patch (Quesnel and Soda Creek).
—. Female genital segment shorter than rest of abdomen, stout; male forceps notched apically. . . . . **trimaculata** Crawford (From Thormanby Island and Esquimalt, by Klyver (1932b) who regarded the variety **astigmata** Crawford as a separate species).
8. Small (2-2.5 mm.) species; genal processes separate basally, strongly divergent; fore-wings more or less fumate 9
—. Larger (more than 2.5 mm.) species; genal processes separate basally, less strongly divergent; fore-wings not usually fumate (except in **pyricola** and **alaskensis**). 10
9. Head and thorax very prominently pubescent. . . . . **hirsuta** Tuthill (From Satus Creek, Washington (Tuthill, 1943)).
—. Head and thorax not pubescent. . . . . **coryli** Patch (From British Columbia (Tuthill, 1943)).
10. Female genital segment distinctly longer than rest of abdomen and male forceps simple . . . 11
—. Female genital segment at most as long as rest of abdomen or, if longer, male forceps not simple. 15
11. Antennae 1 2/3 times as long as width of head or more. 12
—. Antennae 1 1/3 to 1 1/2 times as long as width of head . . . . **buxi** (Linnaeus) (Vancouver).
12. Apex of dorsal valve of female genital segment curved ventrally. . . . . **hartigii** Flor (Recorded from Edmonton, Alberta).
—. Apex of dorsal valve of female genital segment upcurved. 13
13. Ventral valve of female genital segment with sharp apex; large species (4-4.5 mm.). . . . . **stricklandi** Caldwell (Recorded from several localities in Alberta by Strickland (1939)).
—. Ventral valve of female genital segment with blunt apex 14
14. Ventral valve of female genital segment distinctly shorter than dorsal valve, latter evenly upcurved; male forceps arched to black, blunt apices . . . . **magnicauda** Crawford (From British Columbia (Tuthill, 1943)).
—. Ventral valve of female genital segment nearly as long as dorsal valve, latter very abruptly upturned apically; male forceps slender, gradually narrowing to apices. . . . . **tuthilli** (Caldwell) (Recorded by Strickland (1939) from Medicine Hat, Alberta).
15. Antennae slightly longer than width of head. . . . . **parallela** Crawford (Chilliwack, Chilcotin and Nicola Lake, (Klyver 1932b)). (see also couplet 22 below).
—. Antennae at least 1 1/3 times as long as width of head (sometimes slightly less in **alaskensis**). 16
16. Male forceps simple, blunt to acute apically (not truncate); greenish white 17
—. Male forceps not simple. 20
17. Genal processes almost as long as vertex; light green species. . . . . **alba** Crawford (Recorded by Tuthill (1943) from Washington).
—. Genal processes not over 2/3 as long as vertex; dark coloured species. 18
18. Fore-wings with a black spot at apex of clavus, often somewhat fumate. 19
—. Fore-wings immaculate. . **americana** Crawford (Recorded by Tuthill (1943) from Banff Springs, Alberta).
19. Pterostigma narrow. . . . [5]**pararibesiae** Jensen (Recorded by Jensen (1956) from Ellensberg, Washington). (see also couplet 20).
—. Pterostigma large. . . . . **pyricola** Förster (Interior of British Columbia (Downing et al., 1956)).
20. Fore-wings with a prominent dark spot at apex of clavus . . . . [5]**pararibesiae** Jensen (see couplet 19 above).
—. Fore-wings immaculate (except pterostigma may be dark, more or less fumate in **alaskensis**). 21
21. Male forceps narrowed before apex, then enlarged and truncate, somewhat T-shaped in appearance. 22

[5] The species, **pararibesiae**, was described and separated from **ribesiae** (Crawford) by Jensen (1956) along with **notapennis** Jensen. Of these three only one, **pararibesiae**, is recorded from the area of interest; **ribesiae** being recorded from no nearer than Oregon and **notapennis** being restricted to California. From Jensen's descriptions I surmise that the complex of all three species would key out as **ribesiae** in Tuthill's (1943) key. I have therefore retained Tuthill's method of determination as a means of identifying **pararibesiae** in the region being considered here.

—. Male forceps not T-shaped. 23

22. Length to tip of folded wings 3 mm. . . . . **parallela** Crawford (see couplet 15 above).

—. Length to tip of folded wings 3.5 to 4 mm. . . . . **minor** Crawford (Victoria and Vancouver (Crawford, 1914)). (note that **americana flava** = **minor flava** — see Tuthill, 1943).

23. Male forceps broad, apices very broadly truncate and heavily sclerotised. . . . . **latiforceps** Tuthill (Quesnel (Downes, but with a question mark against the determination), recorded by Tuthill (1943) from Easton, Washington).

—. Male forceps otherwise. 24

24. Male forceps strongly sinuate on caudal margin. . . . . **sinuata** Crawford (Recorded from Edmonton and Nordegg, Alberta by Strickland (1938)).

—. Male forceps otherwise. 25

25. Entire apical portion of forceps hooked, heavily pubescent; female genital segment shorter than rest of abdomen. . . . . **uncata** Tuthill (Recorded by Tuthill (1943) from Banff Springs, Alberta).

—. Forceps bearing a small apical hook, scarcely visible in lateral view; female genital segment as long as or longer than rest of abdomen. . . . . **alaskensis** Ashmead (Recorded from Fox Point and Seldovia, Alaska by Tuthill (1943)).

Genus: **Arytaina**

1. Fore-wings conspicuously maculate, spotted or entirely dark. 2

—. Fore-wings not conspicuously maculate, often more or less evenly fumate. 4

2. Fore-wings with prominent pterostigma. . . . . **pubescens** Crawford (Penticton).

—. Fore-wings with pterostigma almost or completely obsolete. 3

3. Fore-wings entirely dark; male forceps bilobate. . . . . **fuscipennis** Crawford (North Bend).

—. Fore-wings white with brown spots or maculae; male forceps not bilobate. . . . . **robusta** Crawford (From British Columbia (Tuthill, 1943)).

4. Pterostigma lacking. . . **spartiophila** (Förster) (Victoria).

—. Pterostigma prominent. . . . **ceanothi** Crawford (Recorded from Easton, Washington by Tuthill (1943)).

Genus: **Psyllopsis**

A single species of this genus is recorded from this region. This is **fraxinicola** (Förster) from Victoria. Tuthill (1943) characterises the species as follows: 'unicolourous, including wings, greenish yellow, wings hyaline'.

Genus: **Euphyllura**

1. Veins Rs and M (including branches) of fore-wings very strongly sinuate; wings brown basally, light apically. . . . . . . **arbuti** Schwartz (Galiano).

—. Veins Rs and M not or only very slightly sinuate; wings generally brownish with red veins. . . . . **arctostaphyli** Schwartz (Merritt).

Note that in the above keys the most exact localities recorded for the species from British Columbia are given. Species occurring in adjacent areas but not within the province are included only when a definite record has been published.

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1 in.=2.54 cm	1 ft^3=28.3 dm^3	1 cm=0.394 in
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1 mile=1.61 km	1 lb/acre=1.12 kg/hectare	1 km=0.621 mile
1 lb.=453.6 g	1 lb/in^2(psi)=70.3 g/cm^2	1 kg=2.2 lb
1 gal (U.S.)=3.785 liters	1 lb/gal (U.S.)=120 g/liter	1 liter=0.264 gal (U.S.)
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TAENIOTHRIPS ORIONIS OVIPOSITION AND FEEDING INJURY ON CHERRIES[1]

R. D. MCMULLEN
Research Station, Canada Department of Agriculture
Summerland, British Columbia

ABSTRACT

Oviposition by overwintered **Taeniothrips orionis** Treherne in the ovaries of cherry flowers and immature fruits during early May caused injury which resulted in dimple-like depressions on the mature fruits. The damage was widespread in the Okanagan Valley in 1971. First brood adults oviposited in cherry fruits during late June and early July but the injury caused at this time was less pronounced. Feeding injury by larvae caused russeting on fruits and chlorotic areas paralleling secondary veins on leaves.

Treherne (1924) described *Taeniothrips orionis* from specimens collected in the lower Fraser Valley of British Columbia on *Acer macrophyllum*, cultivated apple, pear and *Nuttalia cerasiformis*. Bailey (1949) redescribed the species and mentioned that it is most commonly found at high elevations during the spring and summer in the flowers of various shrubs and trees. He listed the distribution of *T. orionis* as British Columbia, Washington, Montana, Wyoming, Colorado and California. Bailey and Knowlton (1949) recorded it from Utah. The first reported instance of economic injury by *T. orionis* was on cabbage, lettuce and potatoes, near Kenai, Alaska (Washburn, 1958). The following describes oviposition injury by adults and feeding injury by larvae of *T. orionis* on cherry.

In mid-May, 1971, approximately 2 weeks after full bloom of sweet cherries, very small depressions similar to a pin prick were observed on cherry fruits. At this time the cherry fruits were approximately 5 mm in diameter and the injury was not very discernible. As the fruits developed the injured tissue around the depressions failed to grow as rapidly as uninjured tissue, which resulted in the formation of dimples (Figure 1). A large number of cherry fruits were dissected during the 3rd week of May and a few thrips eggs were found in small cavities beneath the epidermis at the bottom of the dimples. No adult thrips were found on the cherry trees at this time but 1st and 2nd instar thrips larvae were common on leaves. Adults reared from collections of these nymphs were identified as *T. orionis* by Dr. W. R. Richards, Entomological Research Institute, Ottawa. Presumably overwintered adult *T. orionis* oviposited in the flower ovaries during bloom or shortly after.

In cherry orchards where thrips larvae were extremely abundant, feeding on the epidermis of fruits caused a noticeable russeting (Figure 2). Severely russetted fruits split as they grew due to the inability of the injured epidermis to expand. Larvae feeding on leaves caused the injury shown in Figure 3. The injury was restricted to the lower surface and was most common on young succulent leaves. The injured areas were chlorotic and tended to be distributed parallel and adjacent to secondary veins.

Oviposition injury on fruits was most obvious during the latter 2 weeks of June when the fruits began to color. The dimples turned deep red while the rest of the fruit was pale (Figure 4). When the cherries ripened and the red color was uniform, the dimples were less noticeable (Figure 5).

First generation larvae matured to adults during the 3rd and 4th weeks of June. Females of this generation also oviposited in the fruits. At this time the fruits were nearly full size, therefore the oviposition sites did not develop distinct dimples. The oviposition scars were difficult to differentiate from lenticels until the eggs hatched. After the eggs hatched the scars were slightly larger than lenticels. Eggs were also laid in leaf petioles and main veins. Second brood larvae fed mainly on young succulent leaves and matured to adults during the last week of July and the 1st week of August. No evidence of a 3rd brood on cherry trees was observed.

Injury was more variable between orchards than within orchards, and all varieties of sweet and semi-sweet cherries were susceptible. Approximately 10% of the total cherry crop in

[1]Contribution No. 343, Research Station, Summerland.

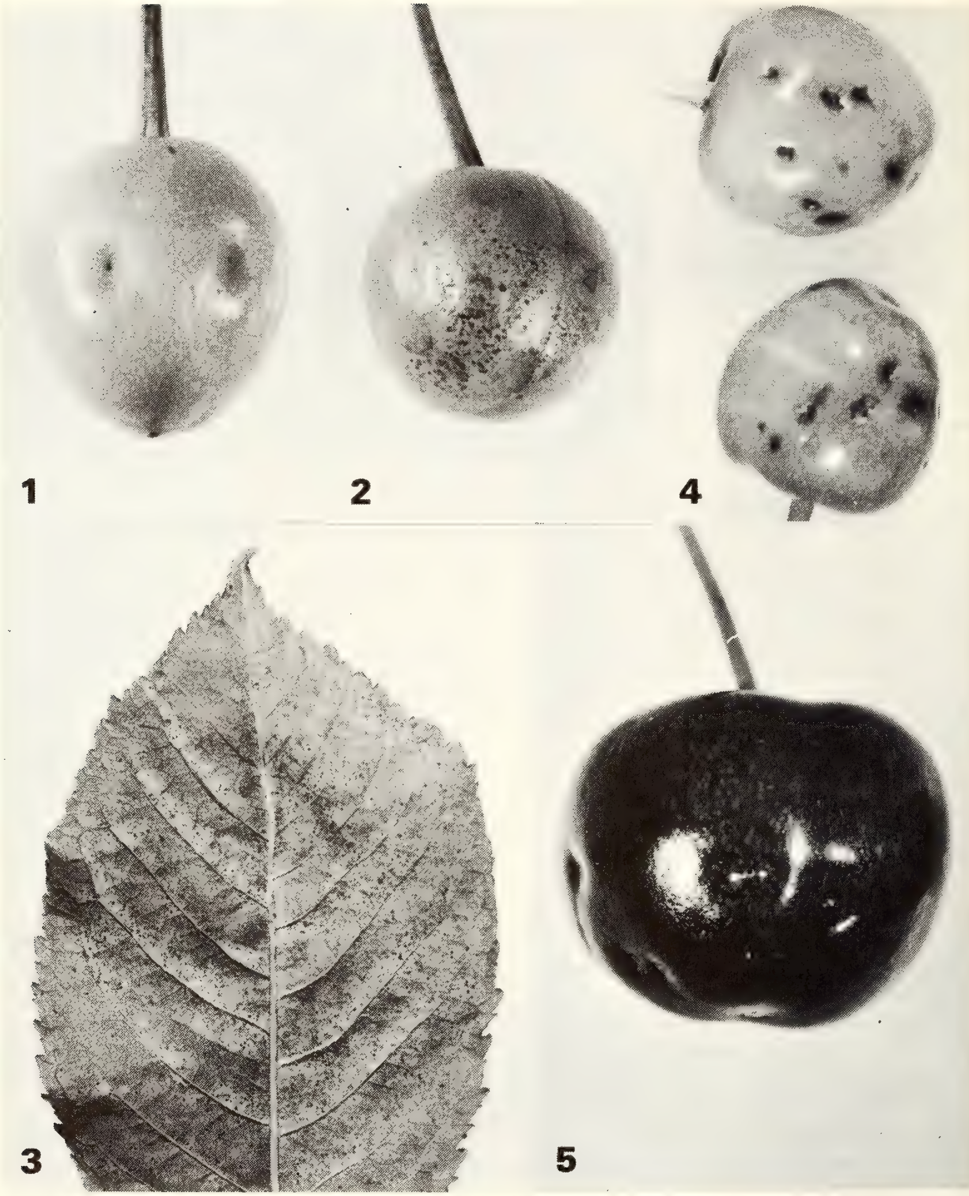

Fig. 1. Dimples on immature fruit caused by oviposition at, or shortly after bloom.

Fig. 2. Larval feeding injury on an immature fruit.

Fig. 3. Larval feeding injury on a leaf.

Fig. 4. Appearance of dimples on fruit in late June. The injured areas were deep red, the remainder of the fruit pale yellowish-green.

Fig. 5. Dimples on a mature fruit.

the Okanagan Valley was affected. Injury varied from 0 to 2% in orchards which were sprayed with diazinon at petal fall for control of fruittree leafroller. Diazinon, 2 quarts 50% E.C. per acre applied on June 29 gave 100% reduction of adult and late instar larvae.

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EROSION OF AZINPHOSMETHYL FROM APPLE LEAVES BY RAIN AND OVERTREE IRRIGATION[1]

A. D. McMECHAN, C. V. G. MORGAN and G. A. WARDLE

Research Station, Canada Department of Agriculture
Summerland, British Columbia

ABSTRACT

Three sprays of azinphosmethyl wettable powder were applied for seasonal control of the codling moth, **Laspeyresia pomonella** (l.), in a semi-dwarf apple orchard. A rain of 1.75 cm, occurring 6 hours after a spray application, removed 41% of the deposit from the leaves; a rain of 1.00 cm, occurring 16 days after an application, did not remove any residue. Residues in the treetops were eroded more rapidly in blocks with overtree irrigation than in those with undertree irrigation. But there was no difference in the erosion rate in the overtree-irrigated orchard whether 5.1 cm of water was applied biweekly or 2.5 cm was applied weekly. There was a trend to poorer control of the codling moth with overtree irrigation.

INTRODUCTION

There has been concern for many years that overtree irrigation of apple trees may remove pesticides and thus reduce control of the codling moth. *Laspeyresia pomonella* (L.). In a small-scale experiment in 1961 with Golden Delicious trees, Williams showed that 1 overtree sprinkling, applied 5 days after a spray of azinphosmethyl, removed a large amount of the residue and that a rain of 0.33 cm that fell 2 days after spraying removed an even larger amount. A number of workers have investigated the influence of rain, or simulated rain, on the removal of other pesticides. Much of this work is summarized by Ebeling (1963) and Linskens, Heinen, and Stoffers (1965). Our experiment, conducted throughout the 1971 growing season, was designed to measure the effects of overtree irrigation on the erosion of azinphosmethyl residues from apple leaves and on the control of the codling moth. The amounts of residue removed by rain were also measured whenever possible.

[1]Contribution No. 342 of the Research Station.

MATERIALS AND METHODS

The experiment was conducted in 3 adjacent blocks (I, II, III) of semi-dwarf apple trees on M.VII rootstocks. There were 8 varieties in each block, planted randomly. Each block consisted of 7 rows with 12 to 15 trees per row. The rows were spaced 4.6 m apart and the trees 2.3 m apart. Height of the trees was about 3.7 m.

Each block was divided into 4 plots of 3 rows each; the 7th row served as a buffer between the sprayed plots. Three sprays of 50% azinphosmethyl wettable powder were applied for codling moth control on 2 June, 23 June, and 28 July, at the currently recommended rate of 0.23 kg / ha in plot I, and at rates of 0.17 and 0.11 kg / ha in plots 2 and 3 respectively. Plot 4 was sprayed with water only: it served as a check on codling moth infestation at harvest and as a blank for residue analysis. No other pesticides were applied during the season. The sprays were applied with an experimental, low-volume, airblast

sprayer using 55 l of water per ha.

The blocks were irrigated from May to September. Block I received 5.1 cm of water every 2 weeks by undertree sprinkling. Blocks II and III were irrigated by overtree sprinkling: block II received 2.5 cm every week and block III 5.1 cm every two weeks. No irrigation was applied until at least 1 week after a spray application.

The following rains occurred during the experiment: 1.75 cm accompanied by strong winds on 2 June, starting 6 hr after the spray had dried; 0.89 cm on 8 June; 1.19 cm on 13 June; 0.15 cm on 22 June; 0.30 cm on 23 June, starting 5 hr after the spray had dried; 0.46 cm on 25 June; and 1.00 cm during 9-10 July.

Leaves for analysis of azinphosmethyl residues were sampled 20 times during the season: before and after each spray application, before and after each irrigation, and following periods of rain. A sample consisted of a total of 25 leaves picked from 4 trees in the centre row of each plot at each of 3 levels: 1.2, 2.3 and 3.4 m above the ground. Azinphosmethyl was determined by the Miles method (1964).

The codling moth infestation at harvest was determined by examining all the fruit on the trees and on the ground for stings and entries. Unfortunately, the crop was light and variable, ranging from 0 to 500 apples per tree.

RESULTS AND DISCUSSION

The initial deposits of azinphosmethyl on the leaves varied widely between blocks, indictating that large differences would be required to show the effects of sprinkling on the erosion of spray deposits. The greatest variation was at the 3.4-m level where the range of spray deposits (ug / cm²) on the 3 spray dates for the 3 application rates was:

Application rates, kg/ha	2 June Range	2 June Average	23 June Range	23 June Average	28 July Range	28 July Average
0.23	1.0-1.6	1.3	0.7-1.8	1.2	1.0-2.1	1.4
0.17	1.1-1.6	1.4	1.1-1.7	1.4	1.2-1.5	1.4
0.11	0.7-0.9	0.8	0.8-0.9	0.8	0.9-1.3	1.1

Figure 1A shows the average residues of azinphosmethyl on the leaves on sampling dates throughout the summer, where blocks were irrigated by undertree and overtree sprinklers. Overtree sprinkling weekly with 2.5 cm of water did not remove any more residue than overtree sprinkling biweekly with 5.1 cm. The residues eroded more rapidly in the overtree-irrigated blocks than in the undertree-irrigated block, but the differences were barely significant (P = 0.05) only at the 3.4-m level.

The following table shows the per cent of the original deposits left on the leaves at the different levels 3 weeks after the spray of 23 June.

There was no significant difference (P = 0.05) between blocks with different irrigation treatments in the percentage of original deposits still remaining at the 1.2 and 2.3-m levels. Evidently the insecticide eroded

Irrigation method	Level in tree m	Initial deposit μg/cm²	Residue on leaves after 3 weeks μg/cm²	% of original deposits remaining on leaves after 3 weeks
Overtree, weekly	3.4	1.21	0.49	40
	2.3	1.45	0.70	48
	1.2	1.19	0.73	61
Overtree, biweekly	3.4	0.87	0.41	47
	2.3	1.39	0.78	56
	1.2	1.02	0.71	70
Undertree	3.4	1.31	0.77	59
	2.3	1.57	0.91	58
	1.2	1.13	0.83	73

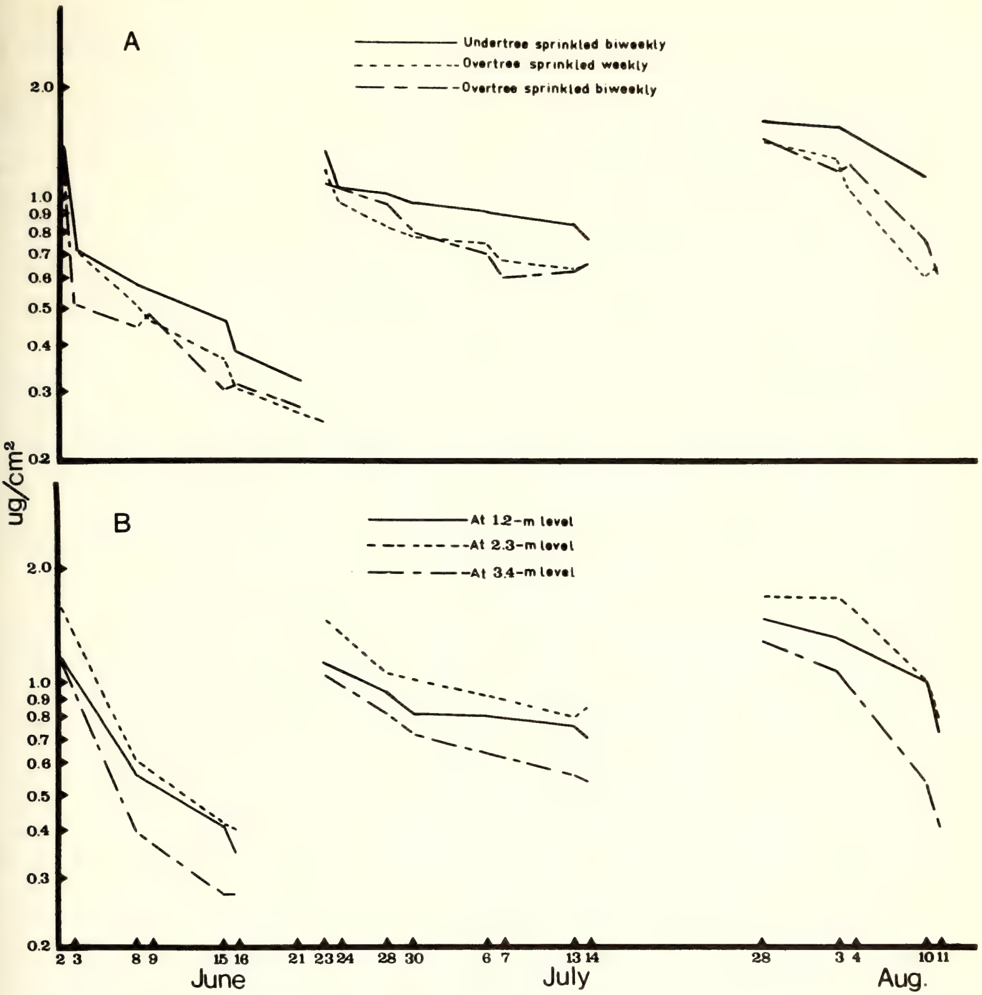

Fig. 1. Average residues of azinphosmethyl on leaves on 20 dates:

A—in blocks irrigated by overtree and undertree sprinklers (insecticide rates and levels in trees combined)

B—sampled from 3 levels in the trees (insecticide rates and irrigation methods combined).

from tree-tops by overtree irrigation was not redeposited on leaves in the lower levels of the trees.

Figure 1B shows the average residues of azinphosmethyl on leaves sampled at 3 levels in the trees throughout the summer. Though residues were highest at the 2.3-m level and lowest at the 3.4-m level, the only instance where the initial deposits at these 2 levels differed significantly ($P = 0.05$) was on 2 June. Regardless of the magnitude of the initial deposits, the residues eroded at approximately the same rate at each of the 3 sampling levels. This agrees with the work of Gunther *et al.* (1946) who found that the rate of decrease of DDT residues is independent of the original deposits.

Rains occurring soon after spray application removed large amounts of insecticide. For example, the 1.75 cm that fell 2 June starting 6 hr after the spray had dried, and lasting for 10 hr, removed 41% of the initial deposit; the much lighter rainfall of 0.30 cm on 23 June, starting 5 hr after spray application, and lasting for 3.5 hr, removed 12% of the inital deposit. When dry weather followed a spray application the erosion rate was much slower. For example, during the dry

1-week period following the spray of 28 July the initial deposit eroded only 7%.

Residues that had been on the leaves for long periods were not eroded as readily as freshly-applied sprays. For example, the average residue on leaves in all plots on 7 July, 14 days after spray application, was 0.65 $\mu g / cm^2$. Though a rain of 1.0 cm fell during 19 hr on 9-10 July the average residue on 12 July was still 0.64 $\mu g / cm^2$. No irrigation was applied between 7 and 12 July.

Overtree sprinkling is likely to have an effect similar to rain on the removal of residue and therefore we believe that overtree irrigation should be delayed as long as possible after spray application. Further work is required to determine how soon overtree irrigation can be applied after spraying without causing serious erosion of spray deposits.

It is interesting to note that azinphosmethyl residues declined more rapidly, and to lower levels, in the wet weather of June than in the drier periods of July and August. Cool temperatures usually occur with the wet weather of June and this extends the period of codling moth emergence. These 2 factors, rapid residue decline and cool wet weather, may explain why good control of first-brood codling moth is not readily obtained in some years.

Because the crop was so light and variable no definite conclusions could be drawn from the codling moth counts. However, there appeared to be no difference in the control achieved with 0.23 and 0.17 kg / ha of azinphosmethyl. Control appeared poorer with 0.11 kg / ha. Percentage codling moth infestation for the 3 rates of azinphosmethyl was 5, 5, and 8, respectively; infestation in the check was 43%. The effect of irrigation method on codling moth control appeared more pronounced; there was a trend to poorer control with overtree irrigation. The infestation in the block sprinkled undertree averaged 2%; in the block sprinkled overtree weekly, 6%; and in the block sprinkled overtree biweekly, 12%. Respective percentages in the checks were 39, 42 and 45.

Acknowledgements

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INSECTICIDES AGAINST TUBER FLEA BEETLE ON POTATOES IN BRITISH COLUMBIA (CHRYSOMELIDAE: COLEOPTERA)

D. G. FINLAYSON, M. J. BROWN, C. J. CAMPBELL,
A. T. S. WILKINSON AND I. H. WILLIAMS[1]

ABSTRACT

To protect potatoes from damage by larvae of the tuber flea beetle, **Epitrix tuberis** Gent., in silt and sandy clay loam soils, carbofuran (Furadan) fensulfothion (Dasanit), and fonofos (Dyfonate) were applied as 12-inch band or broadcast treatments, rotovated to a depth of 4 inches and rows of potatoes planted in the treated areas. Three supplementary drenches were applied at about 2-week intervals to include the emergence period of the second generation adults. In silt loam the untreated and fonofos band-treated plots produced 31 and 40% marketable tubers, respectively, against 92 to 100% for the other treatments. In sandy loam the comparable figures were 0.5 and 4.5% against 10 to 97%. Residues in the tubers ranged from none detected in fonofos treatments to 0.23 ppm of fensufothion and its sulfone in potatoes from the band treatment.

INTRODUCTION

The tuber flea beetle, *Epitrix tuberis* Gent. (Fig. 1C), was present in the lower Fraser Valley by 1940 (Glendenning, 1945) and in the southern interior by 1944 (Neilson and Finlayson, 1953). It became well established and its spread to other potato areas is recorded (Fulton and Banham, 1960). The adults feed on the leaves (Fig. 1B) and the larvae on the tubers (Fig. 1A). Damage by this pest does not cause a reduction in yield, but it reduces the number of marketable tubers.

Early experiments with foliar applications reduced the adult populations and resulted in decreased oviposition (Finlayson and Neilson, 1954). This method was replaced by soil incorporation of persistent cyclodiene organochlorines (Banham, 1960). In coastal British Columbia where late blight and aphids are additional problems, a combined foliar application of a fungicide and an insecticide also controlled the beetles.

In 1964 aldrin and dieldrin failed to prevent larval damage in the Salmon River Valley near Vernon. Experiments in the laboratory showed that the flea beetles were resistant to DDT and dieldrin both there and at Lavington, and to DDT as far north as Pavilion. However, they remained highly susceptible to diazinon and presumably to other organophosphorus compounds (Banham and Finlayson, 1967). By 1970, nearly all organochlorine insecticides had been removed by legislation from agricultural use in British Columbia.

By 1968 Banham (1965, '67, '68) had demonstrated conclusively that none of the organophosphorus or carbamate insecticides investigated could produce more than 50% marketable tubers by single or split applications applied in the soil. In contrast Wilkinson (1968, '69) found that both fonofos (Dyfonate) and carbofuran (Furadan) would protect potatoes from wireworm damage in peat soil. Concurrently Finlayson (1968) had shown that fensulfothion (Dasanit) and carbofuran although excellent soil insectcides, lacked the persistence necessary to protect root crops from the damaging second and third generation of soil insects.

In 1971 the recommendation for tuber flea beetle control was carbaryl (Sevin) in the interior and endosulfan (Thiodan) at the coast, applied as spray or dust at approximately 1 lb/ acre / application at 10-day intervals until harvest. The recommendation for wireworms was fonofos or carbofuran, but conflicting reports of failures of carbofuran in some soils in the interior of British Columbia placed doubt on its efficacy. With these problems in mind experiments were designed to investigate the rates, methods and persistence of these compounds for potato growing.

MATERIALS AND METHODS

In sandy clay loam at Kelowna and in silt loam at Vernon, granular fensulfothion, fonofos and carbofuran were applied to the soil

[1]Research Branch, Canada Agriculture, 6660 N.W. Marine Drive, Vancouver 8, B.C.

surface at 0.66 lb toxicant per acre in a 12-inch band, and at 5 lb toxicant per acre broadcast. The insecticides were rotovated immediately after application to a depth of 4 to 5 inches and seed potatoes of Foundation grade were sown at 1-foot intervals by hand in the treated areas in rows 3 feet apart. Each location included 32 plots consisting of a broadcast and a band treatment for each of the 3 compounds; 1 plot treated with carbaryl (Sevin), the currently recommended treatment; and an untreated plot; all in 4 replications. A plot consisted of 4 rows 25 feet long.

In addition to the granular applications the broadcast and band-treated plots received 3 supplementary sprays at 1 lb toxicant/acre/ application in 100 gal water to wet the plants and the soil about the base of the plant to reduce the population of adults and thus oviposition. The sprays were applied at about 2-week intervals starting in mid-July to coincide with the emergence of second-generation adults. Carbaryl was applied at 1 lb toxicant acre application in 100 gal water when approximately 75% of the plants had emerged and was repeated 9 times at 10-day intervals until 10 days before harvest.

At harvest 100 marketable tubers with a minimum diameter of 1.5 inch, were dug at random from the 2 central rows of each plot. A sub-sample of 50 tubers from each plot was peeled, and the flea beetle damage was assessed by counting the number of larval tunnels. The damage was grouped in 6 categories: 0 larval tunnels; 1 to 4; 5 to 9; 10 to 14; 15 to 19; and 20 or more. Tubers having less than 10 larval tunnels were considered marketable (Banham, 1960). The data were examined by analysis of variance and the results compared by Duncan's multiple range test (Duncan, 1955).

For residue analysis, 10 tubers from each replicate were quartered longitudinally and one quarter from each tuber was put into a plastic bag and frozen. The frozen samples were later macerated in a Waring Blendor, pooled by

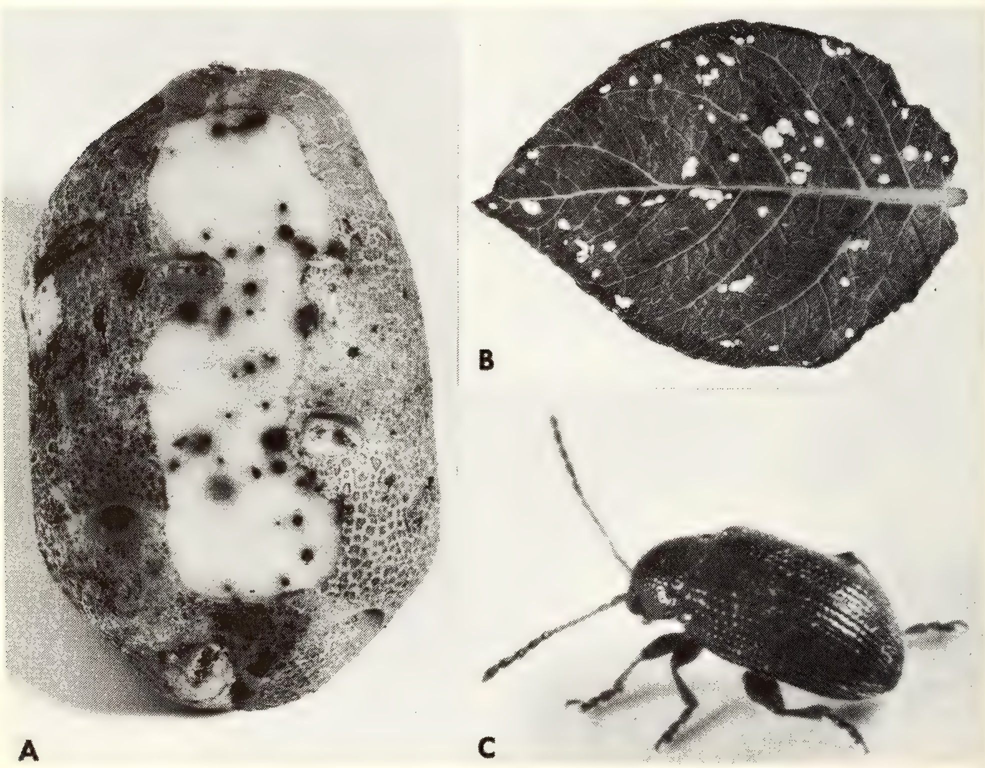

Fig. 1. A. Potato showing severe damage by larvae of tuber flea beetle. B. Holes in potato leaf from adult feeding. C. Tuber flea beetle (X 20).

treatments, mixed thoroughly and held in refrigeration during completion of the analysis. Sub-samples of the various treatments were analysed as follows:

fensulfothion. Determined by the method for carrots of Williams *et al.* (1971) but the second cleanup column containing Norit A and Celite was eliminated. Recovery from fortified potatoes at the 0.2 ppm level was: fensulfothion, 102% and its sulfone 90%.

fonofos. Determined by the same procedure as for fensulfothion except that a 180 cm gas chromatographic column was used instead of the 80 cm one used for fensulfothion. Using this procedure fonofos was eluted in Fraction 1 and its oxygen analog in Fraction 2. Recovery from fortified potatoes at the 0.5 ppm level was fonofos 106% and its oxygen analog 93%.

carbofuran. Determined by a modification of the method for corn stover described by Cook *et al.* (1969). Modifications included substitution of alumina for Nuchar-Attaclay and silica-gel in the cleanup column, and the use of a Coulson conductivity detector instead of a microcoulometric detector. Recovery from fortified potatoes at the 0.1 ppm level was: carbofuran, 81% and 3-hydroxycarbofuran, 90%.

RESULTS AND DISCUSSION

The average population of second-generation adult flea beetles in mid-July was 10 times higher at Kelowna than at Vernon. Foliage feeding and adult beetles were readily seen in the Kelowna plots and tubers from volunteer plants were badly damaged.

Table 1 shows the results of examination of the tubers.

From the table it is clear that 9 applications with carbaryl did not prevent damage under a severe infestation. It was evident also that

TABLE I. Potatoes[1] in each damage category and percentage marketable after various treatments against tuber flea beetles in British Columbia, 1971.

Treatment	Larval tunnels per potato						%
	0	1-4	5-9	10-14	15-19	20+	marketable[2]
Kelowna							
fensulfothion band	74	83	33	6	3	1	95.0 a
" broadcast	108	60	22	8	0	2	95.0 a
fonofos band	0	5	4	12	12	167	4.5 de
" broadcast	27	30	27	19	19	78	42.0 c
carbofuran band	42	58	39	23	19	19	69.5 b
" broadcast	99	75	20	3	2	1	97.0 a
carbaryl	0	12	8	14	14	152	10.0 d
Untreated	0	0	1	3	4	192	0.5 e
Vernon							
fensulfothion band	102	77	17	3	1	0	98.0 a
" broadcast	160	40	0	0	0	0	100.0 a
fonofos band	33	31	15	17	10	94	39.5 b
" broadcast	111	54	19	7	6	3	92.0 a
carbofuran band	100	67	26	4	1	2	96.5 a
" broadcast	160	36	4	0	0	0	100.0 a
carbaryl	147	44	5	3	0	1	98.0 a
Untreated	7	22	33	22	19	97	31.0 b

[1]Fifty tubers, minimum diameter 1.5 inches, from each of 4 replicates, total 200.
[2]Percentages followed by the same letter are not significantly different at the 5% level.

under heavy infestations treatments with fonofos were unable to prevent damage. Even under light attack at Vernon protection given by fonofos was inferior to that given by fensulfothion and carbofuran.

Band treatments had much lighter applications per unit area than broadcast treatments, and they did not give good protection in all cases.

The results of the residue analyses are shown in Table 2. The treatments which afforded the least protection also had the lowest residues. There was no residue of fonofos in the tubers at harvest.

Potatoes from untreated plots, especially at Kelowna, contained both carbofuran and its 3-OH metabolite. Analysis of potatoes from the fensulfothion-treated plots also showed that there was a trace of carbofuran and its 3-OH metabolite present in the samples from Kelowna but little or none in those from Vernon. The explanation appears to lie with weather, irrigation, and the solubility of carbofuran. Rainfall at the Kelowna site was approximately 2 inches in the week preceding application, 0.4 inches immediately after and

TABLE II. Residues in ppm in potatoes after various treatments against tuber flea beetles in British Columbia, 1971.

Insecticides	Kelowna			Vernon		
	Band	Broadcast	Untreated	Band	Broadcast	Untreated
fensulfothion	0.09	0.08	T	0.04	0.09	T
fens.sulfone	0.14	0.10	ND	0.03	0.06	ND
fonofos	T	T	ND	ND	T	ND
fono. O-analog	ND	ND	ND	ND	ND	ND
carbofuran	ND	0.05	0.03	ND	0.03	<0.02
3-hydroxy carb.	0.06	0.15	0.07	0.04	0.07	<0.02

ND = None detected

T = Trace

4.5 inches in June. At Vernon the rainfall was about 30% lower. The rainfall, irrigation, and the topography of the land allowed large areas of the Kelowna site to be inundated for several hours at a time. Although the water solubility of carbofuran is only 700 ppm at 25° C it appears that the residues in the untreated potatoes may have resulted from its systemic properties and the flooding described.

The cost per acre of the two compounds which afforded protection were:

	fensulfothion	*carbofuran*
Broadcast + sprays	$46.90	$49.20
Band + sprays	$20.20	$22.75

Acknowledgements

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RATES, METHODS, AND PERSISTENCE OF INSECTICIDES USED FOR PREVENTING CARROT MAGGOT DAMAGE[1]

D. G. FINLAYSON, M. J. BROWN, C. J. CAMPBELL AND I. H. WILLIAMS

ABSTRACT

Fourteen carbamate and organophosphorus insecticides for preventing damage by carrot maggot, **Psila rosae** (Fab.), were applied as granules in the seed furrow at 2 locations in muck soil, and supplemented with 2, 3, 4, or 8 sprays of the same materials during the season. The spray applications were made at 40 and 70 days after seeding; 30, 50, and 70 days; 30, 50. 70, and 90 days; 40, 70, and 100 days. Diazinon, the currently recommended treatment, was applied 8 times at 10-day intervals from 30 to 100 days. All the granules except chlorfenvinfos and ethion reduced the number of emergent seedlings. The reduction was 40% in plots treated with diazinon, thionazin, Chemagro 7375, Nemacur, pirimiphos-methyl, and TD-8550. Maggot damage was negligible until 100 days after seeding, but by 160 days only plots treated with carbofuran, fensulfothion, ethion and 3 of the numbered compounds had less than 20% damage. Residues of pesticides in the carrots ranged from 0.12 ppm of ethion 30 days after the final application, to 1.28 ppm of thionazin 10 days after. Residues in carrots held in storage at 5°C for 30, 60, and 90 days, increased with the period of storage, except those from plots treated with chlorfenvinphos.

INTRODUCTION

When strains of carrot rust fly, *Psila rosae* (Fab.), became resistant to organochlorine insecticides, experiments were conducted after 1961 to determine methods and rates or applications of insecticides which would prevent damage by the rust fly maggot yet produce carrots free of residues. From 1961 to 1963 promising carbamate and organophosphorus insecticides were applied at various rates in the seed furrow. None was persistent enough to prevent damage for more than a single generation (Finlayson *et al.*, 1964). Further experiments (Finlayson *et al.*, 1966) showed that damage could be reduced below 5% if furrow applications were supplemented by drenches, but the method usually resulted in residues in the carrots at harvest (Finlayson *et al.*, 1970). The only insecticide which protected the carrots from damage without leaving residues in excess of established tolerance was diazinon (Finlayson *et al.*, 1968). However, the need to spray every 10 days from 30 days after seeding to 10 days before harvest made the cost almost prohibitive. Experiments were continued with the most promising compounds to determine effective methods at reduced rates which would lower costs and residues. This paper reports on an experiment designed to investigate the use of fewer sprays at various periods after seeding.

[1]Research Station, Canada Dept. of Agriculture, 6660 N.W. Marine Drive, Vancouver 8, B.C.

MATERIALS AND METHODS

The insecticides used in the primary and secondary experiments are listed alphabetically and identified chemically in Table 1. Common names are used except where these have not yet been assigned. (Kenaga and Allison, 1969).

At two locations in muck soil, granular insecticides at 1 oz toxicant per 1000 row-feet were applied in the furrow with the seed. Carrots, var. Hi Pak, were sown at 0.5 g per 20 feet of row with a V-belt rod-row seeder. The seed and the insecticide were separated in the belt by a fine layer of soil over the seed. In-furrow applications in the primary experiment were supplemented with 2, 3, or 4 sprays (Table 3) at staggered intervals after seeding, at 1 lb toxicant per acre per application in 100 gal water. The schedules were: 40 and 70 days; 30, 50, and 70; 40, 70, 100; and 30, 50, 70 and 90. In-furrow applications of the secondary experiment were supplemented 30, 50, and 70 days after seeding. Diazinon, the currently recommended treatment, was applied in the furrow at 1 oz toxicant per 1000 feet and sprayed 8 times at 10-day intervals starting 30 days after seeding, at 10 oz toxicant per acre in 100 gal water.

Treatments in the primary experiment were randomized and replicated four times at each location. Each plot consisted of four 20-foot rows. Treatments in the secondary or trial experiment were randomized and replicated only twice. The effectiveness of the insecticides

TABLE 1. Chemical definitions of insecticides used for preventing damage by carrot maggots.

Bux	1:4 mixture m-(1-ethylpropyl)phenyl methylcarbamate m-(1-methylbutyl)phenyl methylcarbamate
carbofuran	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate
Chemagro 7375	Unknown
chlorfenvinphos	2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
diazinon	O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
ethion	O,O,O',O'-tetraethyl S,S'-methylenebisphosphorodithioate
fensulfothion	O,O-diethyl O-p-[(methylsulfinyl)phenyl] phosphorothioate
N-2596	S-(p-chlorophenyl) O-ethyl ethanephosphonodithioate
Nemacur	ethyl 4-(methylthio)-m-tolyl isopropylphosphoramidate
pirimiphos-ethyl[1]	2-diethylamino-4-methylpyrimidin-6-yl diethyl phosphorothionate
pirimiphos-methyl[1]	2-diethylamino-4-methylpyrimidin-6-yl dimethyl phosphorothionate
TD-8550[1]	S-(N-methoxycarbonyl-N-methylcarbamoyl-methyl) dimethylphosphonothiolothionate
thionazin	O,O-diethyl O-2- pyrazinyl phosphorothioate
trichloronate	O-ethyl O-2,4,5-trichlorophenyl ethylphosphonothioate

[1]Chemical definitions from Pesticide Research Report 1970 315-332. Compiled by Can. Comm. Pesticide Use Agriculture, Ottawa.

was assessed by counting the number of emergent seedlings in 2 meters of row and by examining scrubbed carrots, harvested 160 days after seeding, for maggot tunnels; one or more tunnels per root constituted a damaged carrot.

At intervals of 10, 30, and 50 days after the final application five carrots were taken from each replicate treated with carbofuran, chlorfenvinphos, ethion, fensulfothion and thionazin. The carrots were washed and placed in frozen storage for analysis. Large samples were also taken 50 days after the final application from the plots treated at 40, 70, and 100-days, then placed in open bags in refrigeration at 5° C. Sub-samples of these were taken after 30, 60, and 90 days refrigeration, washed and put into frozen storage prior to analysis to determine the effect of refrigerated storage on residues.

The frozen samples of treated and untreated carrots were shredded on a Braun Multimix, thoroughly intermixed and 50 g subsamples were analysed as follows:

Chlorfenvinphos, ethion and thionazin were extracted with ethyl acetate following the procedure of Storherr and Watts (1965). Cleanup was by sweep co-distillation (Watts and Storherr (1965)) and analysis was by gas chromatography on a 6 ft column of 4% OV 101 and 6% OV 210 using a flame photometric detector in the phosphorus mode. Recoveries from fortified carrots were as follows: chlorfenvinphos, 1.0 ppm, 97%; ethion, 0.1 ppm, 111%; and thionazin, 1.0 ppm, 82%.

Fensulfothion residues were determined by the method of Williams *et al.* (1971) using flame photometric detection.

Carbofuran analyses were made by modifying the method described by Cook *et al.* (1969) for

corn. The modifications included substitution of alumina for Nuchar-Attaclay and silica gel in the cleanup column, and the use of a Coulson conductivity detector (Coulson, 1966) instead of a microcoulometric detector. Recoveries from fortified carrots at 0.5 ppm were: carbofuran, 101% and 3-hydoxy-carbofuran, 108%.

The percentage solid matter in the frozen shredded carrots after refrigeration at 5 C for 0, 30, 60, and 90 days was determined by two methods. In the first, 100 g samples were oven-dried at 100°C, air cooled and brought to constant weight at room temperature in a desiccator over calcium chloride. In the second, 5 g samples were boiled in xylene and the water collected in a Bidwell and Sterling distilling receiver (1925).

TABLE 2. Average number of emergent carrot seedlings in 2 meters of row after treatments to prevent damage by carrot maggots.

Treatment	Number of seedlings	Treatment	Number of seedlings
Bux	45.0	Nemacur	27.0
carbofuran	51.0	pirimiphos-ethyl	55.0
Chemagro 7375	22.5	pirimiphos-methyl	29.5
chlorfenvinphos	63.5	TD-8550	23.0
diazinon	34.0	thionazin	34.8
ethion	67.3	trichloronate	56.8
fensulfothion	47.0	Untreated	63.0
N-2596	48.5		

RESULTS AND DISCUSSION

Seedling emergence was unsatisfactory for determining the effects of the insecticides on the seeds at the Kennedy location because a layer of blue clay which extended over several plots resulted in very restricted germination. Counts were taken only at the Spranger location. Some effects are recorded in Table 2. Only chlorfenvinphos and ethion treatments produced as many seedlings per unit length of row as untreated plots. Chemagro 7375, Nemacur, pirmiphos-methyl, and TD-8550, all exploratory compounds, had less than half the number of seedlings found in untreated plots. Seedling numbers in the diazinon-treated plots were about half those in untreated plots, a disadvantage to its use since it was first recommended. Thionazin caused similar reductions.

Damage from first and second generation maggots was almost negligible 100 days after seeding. By 130 days damage was evident in untreated and diazinon-treated carrots and at 160 days losses in yield were evident (Table 3). Of the insecticides in the primary experiment only carbofuran, fensulfothion and thionazin were consistently effective in preventing damage. Three sprays at 40, 70, and 100 days appeared to be the best schedule for preventing damage. In the secondary experiment (Table 4) all except N-2596 and pirimiphos-methyl averaged less than 20% damage. Chemagro 7375 and Nemacur had less than 10% damage but their reduction of seedling emergence offset their usefulness.

Residue analysis was restricted to the five most effective insecticides. The results from samples taken 10, 30, and 50 days after final

TABLE 3. Percentage damage by maggots to carrots at 160 days after seeding, using various methods and rates of insecticides in the primary experiment.

Insecticide	Untreated	4 lb (40, 70)	5 lb (30, 50, 70)	5 lb (40, 70, 100)	6 lb (30, 50, 70, 90)	7 lb (30, 40, ...100)[2]	Average
	Rate in lb/acre, and days after seeding sprays were applied ( )						
Kennedy Farms							
Bux	-	38.6	26.2	-	-	-	32.4
carbofuran 5G	-	-	9.3	-	-	-	9.3
carbofuran 10G	-	14.1	11.0	14.1	10.0	-	12.3
chlorfenvinphos	-	16.5	30.4	21.3	31.4	-	24.9
diazinon	-	-	-	-	-	34.7	34.7
ethion	-	18.7	14.9	-	-	-	16.8
fensulfothion	-	8.0	4.0	9.8	7.1	-	7.2
thionazin	-	22.6	10.7	15.5	12.5	-	15.3
trichloronate	-	-	25.0	-	-	-	25.0
Untreated	45.6	-	-	-	-	-	45.6
Spranger Farm							
Bux	-	27.7	35.2	-	-	-	31.4
carbofuran 5G	-	-	11.8	-	-	-	11.8
carbofuran 10G	-	4.7	15.5	0.0	12.4	-	8.1
chlorfenvinphos	-	13.6	34.9	5.9	34.3	-	22.2
diazinon	-	-	-	-	-	28.1	28.1
ethion	-	9.7	19.4	-	-	-	14.5
fensulfothion	-	3.9	6.9	3.9	1.0	-	3.9
thionazin	-	4.6	7.5	4.0	1.0	-	4.3
trichloronate	-	-	28.0	-	-	-	28.0
Untreated	34.8	-	-	-	-	-	34.8

[1]In-furrow granular application plus 2, 3, 4 or 8 sprays.
[2]Eight spray applications.

TABLE 4. Percentage damage by maggots to carrots at 160 days after seeding, in the secondary experiment.[1]

Treatment	Kennedy Farm	Spranger Farm
Chemagro 7375	-	8.9
N-2596	42.0	26.9
Nemacur	12.0	5.7
pirimiphos-ethyl	19.6	14.3
pirimiphos-methyl	68.0	11.0
TD-8550	-	12.3

[1] In-furrow applications followed by 3 sprays 30, 50, and 70 days after seeding.

treatment, are shown in Table 5. Some reduction of residue occurred in this period, probably as a result of dilution by growth, but in most treatments it did not diminish by as much as 50%.

Residues in samples from the 40-70-100 day schedule of treatments taken 50 days after the final application and held at 5°C for 30, 60, and 90 days, are given in Table 6. Except for those treated with chlorfenvinphos there was a general increase in the residues per unit weight over the storage period. We assumed that this resulted from a loss of water by the carrots in storage. Weights of the shredded samples, oven-dried at 100°C, or dehydrated by boiling in xylene, are shown (Table 6). It appears from the results that more than water is removed by the oven-drying method. These results are comparable to those of Bidwell and Sterling (1925) who discuss the advantages and disadvantages of each method. From the table it can be seen that the apparent increase in residue is associated with the change of water content of the carrots during storage. The extra solid matter per unit weight, as determined by the xylene method, ranged from 27.8% for chlorfenvinphos treated carrots to 33.9% for those treated with thionazin. These findings are different from those of Read (1971) who found that until approximately 80 days after planting rutabagas absorbed fensulfothion, which then decreased at a relatively constant rate; and that residues present at harvest decreased quickly to non-detectable levels in storage. Suett (1971) found that from a single application at seeding concentrations above 1 ppm could be present in marketable carrots 12-14 weeks after application at recommended rates. The rates of uptake declined as carrot growth slowed and subsequently the amounts of chlorfenvinphos, diazinon and fonofos residues in carrots changed very little.

In the U.K. Wheatley (1971) and in Canada Finlayson *et al.* (1966) have shown

TABLE 5. Residues in ppm in carrot samples taken 10, 30, and 50 days after the final application of insecticide.

Schedule of drenches	Kennedy								Spranger						
	Days after last application	carbofuran	3-hydroxycarb.	chlorfenvinphos	ethion	fensulfothion	f. sulfone	thionazin	carbofuran	3-hydroxycarb.	chlorfenvinphos	ethion	fensulfothion	f. sulfone	thionazin
40-70	10	ND	.10	.44	.38	.26	.04	.80	.09	.37	.50	.24	.29	.06	1.28
	30	.05	.21	.35	.29	.25	.06	.63	.05	.34	.43	.23	.32	.07	1.17
	50	.06	.06	.30	.20	.26	.10	.57	.04	.22	.24	.20	.18	.07	.73
30-50-70	10	.05	.26	.60	.34	.31	.05	.93	.05	.10	.41	.16	.31	.05	.95
	30	.08	.17	.58	.31	.30	.06	.56	ND	.18	.36	.12	.31	.05	.63
	50	.12	.13	.56	.24	.16	.05	.45	ND	.14	.27	.22	.24	.06	.72
40-70-100	10	ND	.09	.36	-	.34	.05	.76	-	-	-	-	-	-	-
	30	.05	.08	.42	-	.25	.06	.65	.07	.14	.32	-	.45	.14	.56
	50	.04	.06	.41	-	.14	.06	.42	.02	.26	.37	-	.26	.09	.68
30-50-70-90	10	.09	.19	.91	-	.42	.08	1.03	.06	.12	.46	-	.34	.05	1.08
	30	ND	.14	.76	-	.36	.09	.71	.02	.11	.25	-	.31	.08	.94
	50	ND	.21	.42	-	.28	.07	.79	ND	.22	.38	-	.46	.14	.51

ND = None detected

that damage from carrot maggots can be prevented by preseeding applications of pesticides to the soil, by post-emergence applications to the foliage, and by combinations of the two. Regardless of method the carrots have contained objectionable residues at harvest. The results of this experiment are no exception. As long as 50 days after final application, residues close to or above acceptable levels are still present in the carrots when treated at rates and with methods necessary for protection.

TABLE 6. Effect of refrigerated storage for various periods, on carrots harvested 50 days after the final application of insecticide.

Insecticide	Days at 5°C	Percentage solids: Oven dried	Percentage solids: Xylene method	Residues[1]: P	Residues[1]: M	Residues[1]: Total
carbofuran	0	10.56	12.8	0.02	0.26	0.28
	30	11.99	14.0	0.10	0.13	0.23
	60	12.01	14.6	0.06	0.25	0.31
	90	13.67	16.4	ND	0.33	0.33
chlorfenvinphos	0	11.71	13.0	0.37	-	0.37
	30	12.27	14.8	0.05	-	0.05
	60	12.35	15.0	0.10	-	0.10
	90	13.45	16.6	0.07	-	0.07
fensulfothion	0	11.02	12.0	0.26	0.09	0.35
	30	12.21	14.0	0.20	0.08	0.28
	60	12.21	14.6	0.35	0.10	0.45
	90	13.52	16.0	0.51	0.12	0.63
thionazin	0	10.88	12.4	0.68	-	0.68
	30	11.90	14.0	0.82	-	0.82
	60	12.35	14.4	0.60	-	0.60
	90	12.68	16.6	1.08	-	1.08

[1]P = Parent compound, M = Metabolite, ND = None Detected

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THE FUNGI *BEAUVERIA BASSIANA* AND *METARRHIZIUM ANISOPLIAE* IN CULTURES OF THE ROOT WEEVIL *NEMOCESTES INCOMPTUS* HORN (COLEOPTERA: CURCULIONIDAE)

W. T. CRAM

Research Station, Canada Department of Agriculture
Vancouver, British Columbia

The woods weevil, *Nemocestes incomptus* Horn, is a native root weevil which causes serious damage to strawberries in coastal British Columbia. Freshly emerged adults were collected in large numbers from a strawberry planting in early September 1971, and confined in screen-covered quart sealers in the laboratory at room temperature. About 200 adults were kept in each sealer and fed fresh wet strawberry foliage daily. By early October most of the adults had died. White fungus was seen at their leg joints and mouthparts. When apparently healthy, freshly collected adults were confined singly with a dead, fungus-covered adult they died within two to three days. The fungi on the dead weevils were identified as *Beauveria bassiana* (Fig. 1A) and *Metarrhizium anisopliae* (Fig. 1, A and B). These fungi are well known and have many insect hosts. The importance of these fungi in controlling root weevil adults or larvae in the field is not known but warrants further investigation.

Acknowledgement

Gerard M. Thomas, Division of Entomology, University of California, Berkeley, kindly identified the fungi.

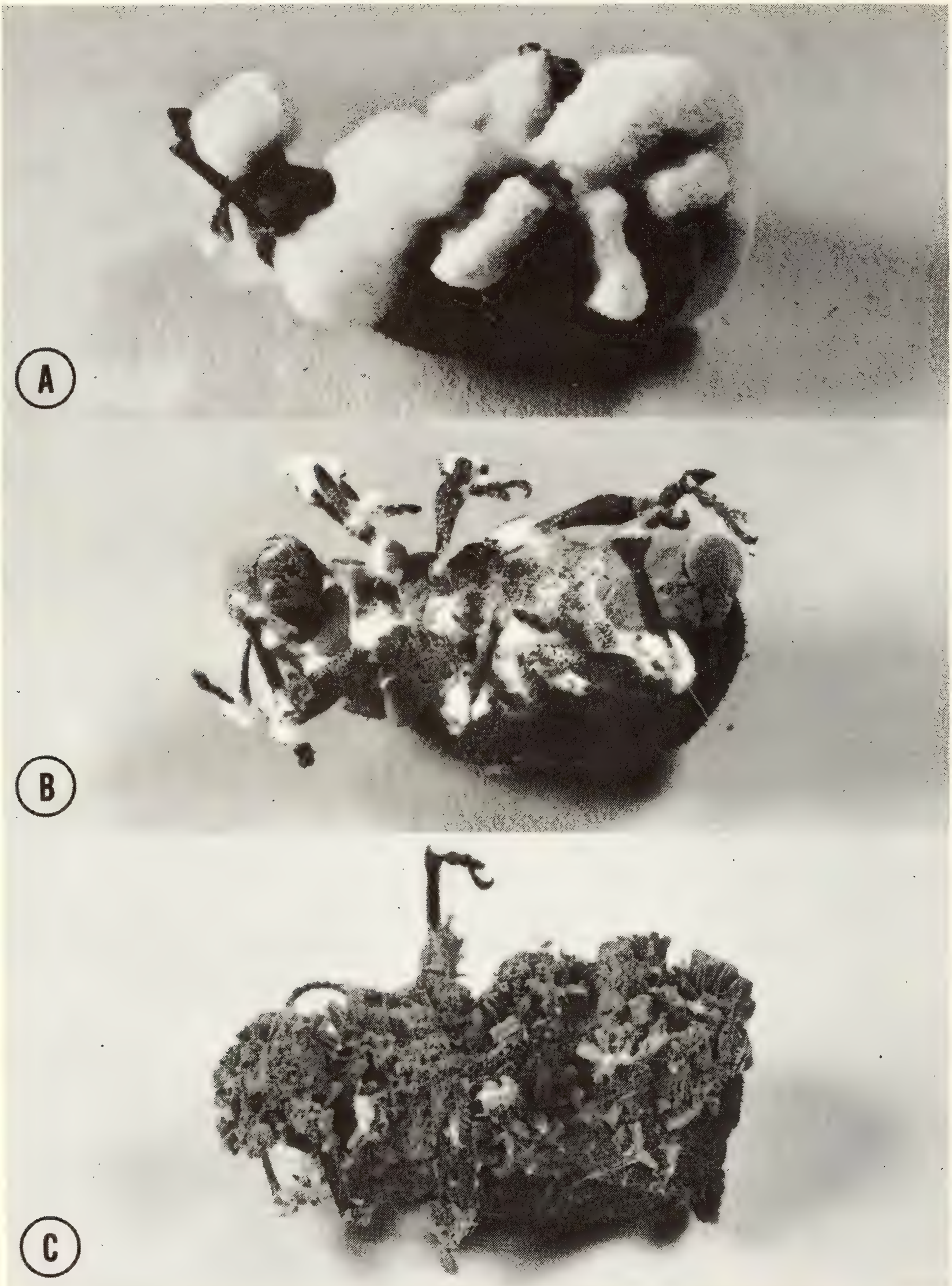

Fig. 1. A. **Beauveria bassiana** on **Nemocestes incomptus** adult.
B. Early stage of **Metarrhizium anisopliae** on **N. incomptus** adult.
C. Late stage of **M. anisopliae** on **N. incomptus** adult showing prismatic masses of spores.

A SIMPLE AND EFFICIENT METHOD OF REARING APHIDOPHAGOUS HOVERFLIES (DIPTERA: SYRPHIDAE)

B. D. Frazer[1]

ABSTRACT

Syrphid larvae and their aphid prey are reared together with minimal maintenance on caged broad bean plants. An essential feature of the cage for adults is a feeding platform raised well off the floor for the diet of cube sugar, water and freeze-dried pollen. Since mating occurs in flight, the cage must be higher than wide or deep.

INTRODUCTION

During investigations on the biotic mortality agents of aphids, the predators most often present in southwest British Columbia were syrphid larvae. Before their importance to aphid control could be assessed it was necessary to rear the various species in numbers for laboratory studies.

Few species of aphidophagous syrphids have been reared successfully because of their dietary and behavioral requirements; the adults need carbohydrate and protein to mature their eggs and the larvae need living aphids. The food of the adult is usually pollen and nectar. Sugar or honey water are substitutes for nectar, but in practice the adults often stick to gauze or paper wetted with sugary solutions. The collection of enough aphids to feed larvae is time consuming and not efficient if the feeding is done without plants, because many aphids die before they are eaten.

The rearing system discussed here solves these problems and has been very successful with the species studied.

METHODS AND MATERIALS

Unopened catkins of hazelnut trees *Corylus* sp. were collected in April, placed over radiators on sheets of paper and allowed to open. The dried catkins were screened and the pollen collected, freeze-dried and vacuum-packed in glass ampoules sealed with heat.

Gravid females, caught in the field, were brought into the rearing room, and allowed to oviposit on leaves or plants infested with aphids. The rearing room was maintained at 20+0.5C, 70-80% RH and light was provided 16 hr per day. When the eggs hatched, the larvae were allowed to feed for 1 or 2 days before being transferred with a moist # 00 sable hair brush, to newly-sprouted broad bean plants, *Vicia faba* L. var. Exhibition Long Pod, growing in UC mix C, Fertilizer I (Matkin and Chandler, 1957) in 15 cm round, plastic pots. One larva was transferred to each plant in each pot. Nine pots were set in a cage for rearing the larvae and the plants were heavily infested with the pea aphid, *Acyrthosiphon pisum* (Harris). Within 10 to 14 days when the larvae had matured and pupated in the soil, the plants were cut down, and the soil was allowed to dry out. After a further 21 to 28 days the adults emerged, and were transferred to another cage (Fig. 1) and fed cube sugar, water and hazelnut pollen (Fig. 2). In 4 or 5 days, broad bean plants 10 to 15 cm high and infested with the black bean aphid, *Aphis fabae* Scopoli, were placed in the cage with the adults and left for 3 or 4 hr. The eggs produced were then handled as described for eggs from field-caught flies.

The cages for the adults are 45 cm wide, 60 cm long and 75 cm high and have a 20 x 20 cm platform 35 cm from the floor. The two side walls are of saran screening, the back and top of Kodapak clear sheets, and the front of wood with a 15 x 15 cm hole covered by a sliding door.

The cover of the cages for the larvae rests on a 15 cm high stand. The dimensions are 50 cm wide, 60 cm long and 30 cm high. The sides are covered with saran screening and the top with Kodapak. The top of the stand has 9 holes in it so that when the pots are in place, they are suspended in the holes by their rims over watering trays.

DISCUSSION

Black bean aphids are ideal for stimulating oviposition because they are small, sedentary, and not easily dislodged from the plant. If pea aphids are used for this purpose many are knocked or fall from the plants and wander about the cage causing the syrphids to oviposit on the cage. However, pea aphids are well suited as prey for the larvae because they are large, have a rapid rate of population increase, and are not toxic to the plants or to the syrphid larvae. Their mobility allows them to use all available areas of the plant.

[1]Research Station, Canada Dept. of Agriculture, 6660 N.W. Marine Drive, Vancouver 8, B.C.

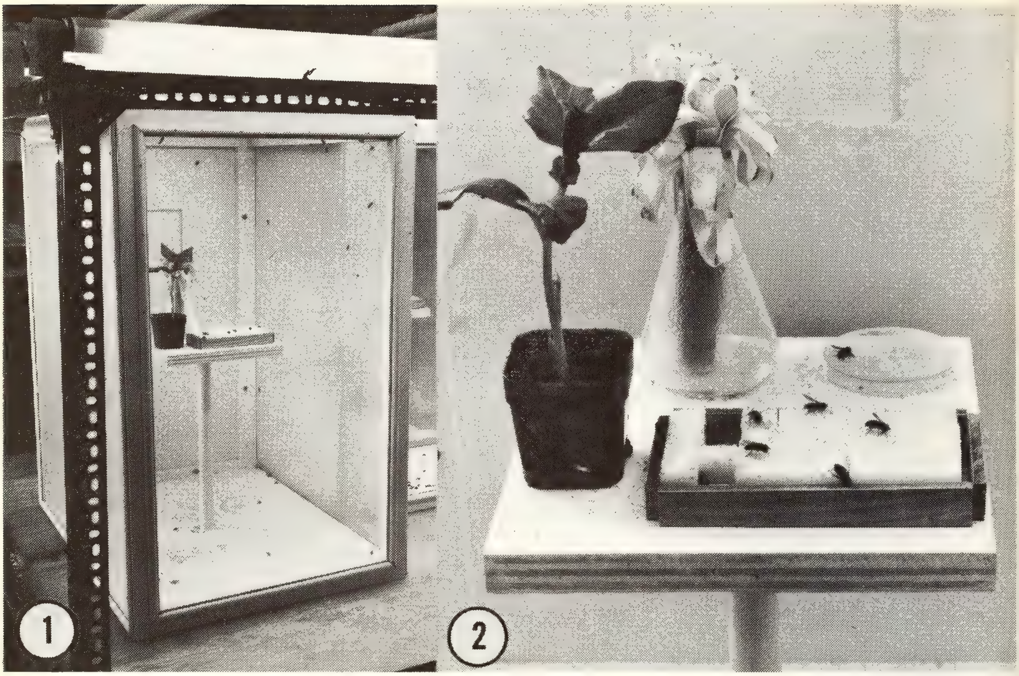

Fig. 1. Cage for rearing adult aphidophagous syrphids.
Fig. 2. Elevated feeding platform in the cage.

Female flies can produce eggs more or less continuously but it is best not to allow them to do so. If eggs are laid over an extended period or are very numerous, the larvae will eat the unhatched eggs and smaller larvae. Provision of an infested plant for 8 hr twice a week results in large numbers of eggs of the same age. Newly hatched, uniform larvae are left on the plants to feed because they are easier to transfer when they have grown.

The combined rearing of the larvae and aphids eliminates the need for mass rearing of the prey species, which is usually the limiting factor in rearing predators. Set up correctly, the 9-pot cages are well balanced predator-prey ecosystems and no further addition of aphids is needed. Emerging adults reach the surface of dry UC mix quicker than if soil is used. Cutting the plants makes their capture easy.

The large size and shape of the adult cage (Fig. 1) and presence of the platform (Fig. 2) are essential features, for most syrphids mate in flight and seldom visit the floor of a cage. In small cages without platforms, the adults flew only if frightened and seldom fed.

The adult diet of dry sugar cubes, tap water and freeze-dried vacuum-packed pollen produced the best results and was the simplest of the diets tested. Yeast, soya bean flour, and yeast hydrolysate mixtures became caked on the flies' feet and abdomens, and condensed milk and molasses mixtures on bread, saran paper or cheese cloth trapped the flies. Honey and sugar solutions were accepted by the flies but they were messy and required frequent attention and renewal. With the method described routine maintenance involves only the refilling of the water flask every second day, bi-monthly replacements of the sugar cubes and bi-weekly additions of pollen.

Species successfully reared by this method were: *Syrphus torvus* O.S., *S. ribesii* (L), *S. opinator* O.S., *Metasyrphus* spp., and *Scaeva pyrastri* (L).

Acknowledgements

I am grateful to Dr. J. R. Vockeroth, Entomology Research Institute, Canada Department of Agriculture, Ottawa for identifying the syrphid species.

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AGGREGATION SITES AND BEHAVIOR OF TWO SPECIES OF *HIPPODAMIA* (COLEOPTERA: COCCINELLIDAE) IN SOUTH-CENTRAL BRITISH COLUMBIA

G. J. FIELDS[1] AND R. D. MCMULLEN[2]

ABSTRACT

Hippodamia caseyi Johnson and **H. oregonensis** Crotch overwinter in aggregation sites on mountain tops in south-central British Columbia. Each species selects distinctive overwintering sites. During the summer, **H. caseyi** is distributed mainly in the valleys and lower mountain elevations, particularly in irrigated alfalfa fields. **H. oregonensis** is restricted to subalpine and alpine areas during the summer. Availability of suitable overwintering sites may be a limiting factor in the abundance of **H. caseyi.**

INTRODUCTION

Many species of Coccinellidae are recognized as important and valuable predators of insect and mite pests throughout the world. However, in the Okanagan region of British Columbia this group of insects has received only passing attention from economic entomologists.

Successful pest control through the pest management concept depends largely upon manipulation of crop ecosystems, making maximum use of natural enemies of pests. To this end, it is essential to attain a more complete knowledge of the life histories and factors affecting the abundance and efficiency of beneficial species. The object of this investigation was to study the life histories and habits of two species of *Hippodamia* that form hibernation aggregations on mountain tops in south-central British Columbia.

METHODS

From the last week of May through October 1970, various agricultural crops, native plants and mountain top aggregation sites were examined periodically for the presence of coccinellids. The sweep net and beating tray methods were used to sample vegetation for beetles. Intensive sampling from the valley to the tops of the mountains was done during periods of dispersal and assembly of the beetles at the aggregation sites.

The area examined was the Okanagan Valley from Osoyoos north to Summerland including the highest mountains immediately to the east and west. The elevation of the valley in this area varies from 278 m in the south to 343 m in the north. The elevation of the highest mountain in the area is 2303 m. Annual precipitation at Osoyoos and Summerland averages approximately 20 and 27 cm respectively. At higher elevations the annual precipitation is much greater and occurs mostly as snow. The climax vegetation of the valley is yellow pine, sage brush and antelope brush. However, much of the valley bottom has been modified by irrigated farming. The major crops are pome fruits, stone fruits, grapes, corn, alfalfa and vegetables. With increasing elevation, east and west, the climax vegetation changes to Dry Forest with yellow pine, Douglas fir and western larch; to Subalpine Forest with lodgepole pine, aspen, Englemann spruce and alpine fir; to Alpine Arctic at the highest elevations with dwarf willows, saxifrages and false heathers.

OBSERVATIONS AND DISCUSSION

Aggregation Sites. Overwintering aggregation sites of *Hippodamia caseyi* Johnson were identified on five mountains: Baldy Mountain (2303 m), Mount Kobau (1975 m), Beaconsfield Mountain (2196 m), Apex Mountain (2248 m) and Sheep Rock (2200 m). Overwintering aggregations of *Hippodamia oregonensis* Crotch were also found on all of these mountains except Mount Kobau. *H. caseyi* was the most abundant species on each of the mountains except on Sheep Rock.

The aggregation sites of the two species differed both in physical features and location. Typically, the sites occupied by *H. caseyi* were located on the south facing upper-most slopes of the mountains, among fractured boulders covered with lichens. The beetles clustered in crevices between the rocks. The crevices were, in almost all cases, free of soil and vegetation.

[1]Pestology Centre, Dept. of Biological Sciences, Simon Fraser University, Burnaby 2, B.C.; Present address, Mid-Columbia Experiment Station, Hood River, Oregon, U.S.A.

[2]Canada Department of Agriculture, Research Station, Summerland, British Columbia.

Rocks lying on, or partially buried in soil, but with cavities under them were never found to shelter beetles. The aggregation sites become free of snow earlier in the spring than most other parts of the mountain tops because of their southerly exposure and the combined effects of topography and wind which result in shallow snow packs.

H. oregonensis aggregation sites were located in all quadrants on the upper-most slopes of the mountains. Typical sites were beneath rock slabs lying on, or partially buried in soil but with crevices beneath them and with grasses and sedges growing immediately around them. The aggregation sites were always in areas where exposure to winds result in relatively shallow snow packs.

In most instances both species were present in any one aggregation, but the minority species usually represented less than one percent of the total. Only the two above-mentioned species were found in aggregations on the mountain tops.

Observations of the aggregation sites in early June, when large snowfields were still present and in mid-October when the first permanent snow had fallen, indicated that both species remain in the aggregation sites through the winter. In western Washington, Edwards (1957) described large swarms of *H. oregonensis* near the summits of Pinnacle Peak in June, 1952, and on Yakima Peak in September, 1952. He also noted large numbers of dead beetles beneath slabs of rock. He assumed that these had been trapped and killed by cold weather and that the beetles normally returned to lower elevations to hibernate. Chapman (1954) and Chapman *et al.* (1955) reported large aggregations of ladybird beetles, including *H. caseyi* and *H. oregonensis* near the summits of several mountains in western Montana. Indirect evidence was noted that the beetles remained at these aggregation sites through the winter.

Dispersal from Aggregation Sites. Dispersal of beetles of both species from the aggregation sites began in early June when there were still extensive snow fields on the upper mountain slopes but the aggregation sites were free from snow. The vigor and rapidity of dispersal of the two species differed. Adult *H. caseyi* flew strongly in a downhill direction at low elevations above the ground. Within a week of the first flights a few *H. caseyi* were collected in the valley. However, samples taken from the valley to the mountain tops indicated that the rate of dispersal of the main body of beetles from the aggregation sites was slow. Dispersal of *H. caseyi* from Mount Kobau, the lowest peak, was complete by mid-June and from Baldy Mountain, the highest peak, by the end of June. On Baldy Mountain, however, a few aggregations of from about 50 to 500 beetles remained *in situ* through the summer. During July and August, *H. caseyi* adults and immature stages were found at all elevations from the valley to the upper slopes of the mountain but with the greatest population densities occurring at or near the valley bottom, particularly in alfalfa fields.

Dispersal activity by *H. oregonensis* began at the same time as *H. caseyi* but the rate of dispersal was slower. Flights by beetles leaving the mountain top were random in direction and of short duration which resulted in a gradual spread downward from the upper slopes. For a few weeks after dispersal began, adults of *H. oregonensis* were most commonly found feeding on the pollen of wild flowers, particularly *Ranunculus* spp., from near the tops of the mountains down to about 1800 m. Reproduction occurred on a number of species of shrubs and herbs through July and August. *H. oregonensis* apparently is a subalpine to alpine species because it was not found at elevations lower than 1700 m.

Formation of Aggregations. The movement of beetles to the mountain top aggregation sites was gradual, beginning in early September and ending by mid-October when the first permanent snow occurred. During early September, adults of *H. caseyi* were most commoly observed feeding on aphids on plants between the elevations of 400 m to 900 m but rarely at higher elevations. Through September to mid-October, numbers at the lower elevations decreased to nil while the numbers seeking shelter in aggregation sites on the tops of the mountains gradually increased.

No attempt was made, during this study, to estimate absolute numbers of each species in the aggregation sites. This was partly due to the physical impossibility of moving sufficient rock and partly because of the fear of disturbing too much of the aggregation sites and thus destroying their attractiveness for the beetles. On the five mountain tops, *H. caseyi* was on the average about one thousand times more abundant than *H. oregonensis*. *H. caseyi* was more abundant on Baldy Mountain than any of the others. On this mountain top a very

rough estimate of the volume of beetles present in the third week of June was 5000 cm^3.

It is apprent from this investigation that *H. oregonensis* is of no value as a predator of aphids on cultivated crops because of its restricted distribution. It may be important in the natural control of aphids on subalpine and alpine ranges. *H. caseyi* may be of value, however, as a predator of aphids on cultivated crops, particularly alfalfa.

This investigation also suggests that the availability of suitable aggregation sites may be a limiting factor in the natural abundance of *H. caseyi*. The number of mountains of sufficient altitude and with features suitable for aggregation sites for *H. caseyi* are limited and the area comprising the five mountain top aggregation sites is very small compared with the total of the whole study area. It is hoped that this report will stimulate further investigation into the feasibility of manipulating *H. caseyi* populations to benefit aphid control on agricultural crops in south-central British Columbia.

Acknowledgements

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INNERVATION OF THE STYLETS OF THE PEAR PSYLLA, *PSYLLA PYRICOLA* (HOMOPTERA: PSYLLIDAE), AND THE GREENHOUSE WHITEFLY, *TRIALEURODES VAPORARIORUM* (HOMOPTERA: ALEYRODIDAE)[1]

A. R. FORBES

Research Station, Canada Department of Agriculture,
Vancouver 8, British Columbia

ABSTRACT

The fine structure of the stylets of the pear psylla, **Psylla pyricola** Foerster, and the greenhouse whitefly, **Trialeurodes vaporariorum** (Westwood), is described from sections studied in the electron microscope. Their mandibular stylets are innervated, each containing two dendrites.

INTRODUCTION

The discovery of nerves in the stylets of aphids (Forbes, 1966, 1969; Parrish, 1967; Saxena and Chada, 1971), an adelgid (Forbes and Mullick, 1970), a leafhopper (Forbes and Raine, in press), and in *Rhodnius* (Pinet, 1963, 1968) suggested that the stylets of all the Hemiptera-Homoptera may be innervated. The present paper demonstrates nerves in the stylets of a representative of each of the Psylloidea and Aleyrodoidea, two superfamilies of the Homoptera in which innervation of the stylets has not previously been shown.

The pear psylla, *Psylla pyricola* Foerster, and the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), are the subjects of the present report.

MATERIALS AND METHODS

Adult pear psylla were from pear and adult greenhouse whiteflies were from fuschia. The heads were dissected from the insects, fixed in 5% glutaraldehyde, post-fixed in 1% osmium tetroxide, and dehydrated in a graded series of ethanol. The pear psylla heads were embedded in Spurr Low-Viscosity Embedding Medium (Polysciences, Inc., Warrington, Penna.). The whitefly heads were embedded in Epon 812 by the method of Luft (1961). Sections were cut with glass knives on an LKB Ultrotome III, mounted on grids with carbon-colloidion supporting films, and subsequently stained

[1]Contribution No. 248, Research Station, 6660 N.W. Marine Dr., Vancouver 8, British Columbia.

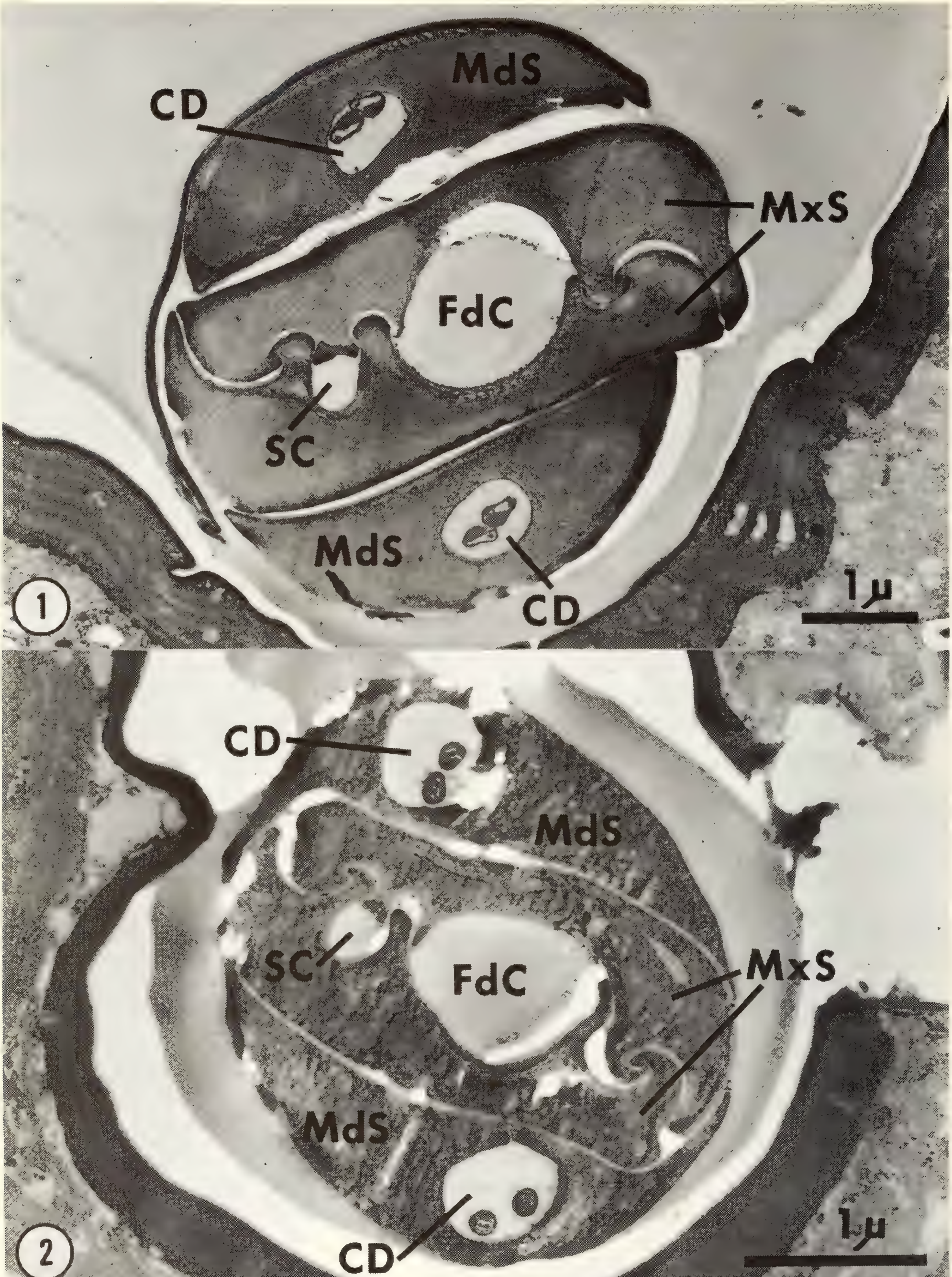

Fig. 1. Electron micrograph of a cross-section of the stylet bundle of a pear psylla, **Psylla pyricola** (Foerster). Each central duct contains two dendrites. CD, central duct; FdC, food canal; MdS, mandibular stylet; MxS, maxillary stylet; SC, salivary canal.

Fig. 2. Electron micrograph of a cross-section of the stylet bundle of a greenhouse whitefly, **Trialeurodes vaporariorum** (Westwold). Each central duct contains two dendrites. The cell membranes and pair of neurotubles of each dendrite are clearly visible, as is the cuticular sheath surrounding the dendrities. Abbreviations as in Fig. 1.

with uranyl acetate and lead citrate. They were examined in a Philips 200 electron microscope.

RESULTS AND DISCUSSION

The mouthparts of the pear psylla and greenhouse whitefly are similar to those of other Homoptera, a fact undoubtedly associated with the uniform piercing and sucking phytophagous feeding habits of the group. The mouthparts consist of two pairs of chitinous needle-like stylets, a labium, and a labrum. The stylets are well adapted for piercing plant tissue and for extracting juices.

The basic structure of the stylets of the pear psylla and the greenhouse whitefly is remarkably similar. In cross sections of their stylet bundles (Figs. 1 & 2), the outer pair is the mandibular stylets; the inner is the maxillary stylets. The whole stylet bundle is compact since the inner surfaces of the mandibular stylets are contoured to conform with the outer surfaces of the maxillary stylets. In the greenhouse whitefly, marked projections at the margins of the mandibular stylets wrap around the maxillary stylets to aid in the coaptation of the stylet bundle. The maxillary stylets of both are interlocked by a series of ridges and grooves to form the larger food canal and the smaller salivary canal between their apposed inner surfaces. The maxillary stylets are not bilaterally symmetrical. The salivary canal is contained almost entirely in one stylet, the other forming only the closing wall. The food canal is centrally located, formed by the apposition of the food canals in both maxillary stylets. Midway in the stylet bundle of the pear psylla, the salivary canal is approximately 0.5μ in diameter and the food canal is approximately 1.5μ in diameter. In the greenhouse whitefly the salivary and food canals are smaller, measuring 0.25μ and 0.9μ respectively. When the insects feed, saliva is pumped down the salivary canal and plant sap is sucked up the food canal. The functional mouth, then, is at the tip of the maxillary stylets.

The mandibular stylets have a central duct running from the base to near the tip. Midway in the stylet, the diameter of this duct is approximately 0.75μ in the pear psylla and 0.6μ in the greenhouse whitefly. The central duct in each mandibular stylet contains two dendrites. Each dendrite consists of a cell membrane, neurotubules, and a structureless material, probably a fluid, which surrounds the neurotubules. The dendrite itself is closely surrounded by a cuticular sheath. The central duct is probably filled with fluid in life, but appears empty in fixed sections. The fine structure of the dendrites is particularly clear in the section of the stylet bundle of the greenhouse whitefly (Fig. 2). The maxillary stylets do not contain nerves.

For many years, stylets of the Hemiptera-Homoptera were generally considered to be needle-like non-living, chitinous bristles. The existence of central ducts in the mandibular stylets was known, but nerves were not associated with them until Pinet (1963) showed bipolar neurons in the bases and nerves running into the shafts of both the mandibular and maxillary stylets of *Rhodnius prolixus* Stål. Forbes (1966, 1969) later traced two dendrites from the base to near the tip of the mandibular stylets of the green peach aphid, *Myzus persicae* (Sulzer). There were several previous indications of the existence of these nerves in aphids. Bradley (1960, 1962) found that amputating the tip of a mandibular stylet or inserting the intact stylet tip into various solutions prevented feeding but greatly increased larviposition. He suggested that this response demonstrated the presence of nerves in the stylets and observed that their central duct contained material that could be pulled as a thread from the cut end of the stylet. Wensler (1962) showed that the cabbage aphid, *Brevicoryne brassicae* (L.), perceives the specific feeding stimulus, sinigrin, with the stylets after they have penetrated the leaf surface.

The nerves in the stylets are undoubtedly of fundamental importance in the selection of hosts and feeding sites and in otherwise monitoring substrates at the stylet tips. Probing and feeding behavior, which has been well studied in aphids, indicates that these nerves supply contact chemoreceptors. Indeed, the work of Wensler (1962) mentioned above seems to confirm this concept.

Both the pear psylla and greenhouse whitefly are virus vectors. Their stylets and method of feeding are ideally suited for the acquisition and transmission of plant viruses. The pear psylla has been shown to transmit pear decline virus (Jensen *et al*, 1964) and the greenhouse whitefly is the vector of beet pseudo-yellows virus in California (Duffus, 1965). More than 25 other plant virus diseases are transmitted by other whiteflies (Costa, 1969).

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BIOLOGICAL NOTES ON A GREEN FRUITWORM, *LETHOPHANE GEORGII* GRT. (LEPIDOPTERA: NOCTUIDAE), ATTACKING APPLES IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA[1]

HAROLD F. MADSEN
Research Station, Canada Department of Agriculture
Summerland, British Columbia

ABSTRACT

For the past 3 seasons a green fruitworm, **Lithophane georgii** Grt., has injured apples in the Okanagan Valley of British Columbia. Larvae feed on leaves, will attack fruit early in the season causing deep russeted pits similar to those caused by the fruittree leafroller, **Archips argyrospilus** (Walker). Larvae were active from late April to early June. Pupation took place in the soil, and adults emerged in October. The insect apparently overwinters as an adult and deposits eggs early in the spring, although eggs of this species have not been found in the field.

Although larvae of **L. georgii** are capable of injuring apples observations in 1970 and 1971 indicate the numbers are so low that the species cannot be considered a major pest.

INTRODUCTION

For several years, periodic reports have been received of injury to apples caused by a large lepidopterous larva referred to by orchardists as a cutworm or a fruitworm. A survey of several apple orchards in 1970 and 1971 showed that a green fruitworm was present in limited numbers. In most instances, the fruitworms were associated with infestations of the fruittree leafroller, *Archips argyrospilus* (Walker). Both pests caused deep russeted pits in apples and the injury caused by the two insects could not be distinguished from one another on mature apples at harvest.

Green fruitworms are the larval stages of several species of moths belonging to the family Noctuidae which attack apple trees and characteristically eat deep holes in the fruit (Rings 1965). The fruitworm responsible for injury to apples in the Okanagan Valley was identified as *Lithophane georgii* Grt. by E. W. Rockburne (Entomology Research Institute, Ottawa, Canada). This species was first described by Sanders and Dustan (1919) in Nova Scotia where it was reported to attack apples. Crum (1956) gives its distribution as both the eastern and western U.S. and the adjacent provinces of Canada. Food plants for this species are listed as apple, antelope brush, ocean spray, alder and raspberry.

FIELD OBSERVATIONS ON BIOLOGY

In apple orchards in the Kelowna district of British Columbia, larvae of *L. georgii* were found feeding on developing apple leaves and blossoms at the pink bud stage of tree development. After bloom, they were found in loosely rolled leaves fastened with silk. They fed principally upon foliage, but also fed on the flesh of adjacent developing apples. This behavior is similar to that of the fruittree leafroller. Fruitworm larvae were found on apple trees from late April to early June and their distribution within an orchard was very spotty. In a routine examination for fruittree leafroller larvae in an apple orchard at Kelowna, 50 clusters on 108 trees were checked and green fruitworms were found in only 10 trees. One tree had more than 50 larvae and an average of only 2 per tree were recorded on the other 9 trees. A similar pattern of distribution was found in other apple orchards. The larvae are not gregarious, as they were always found singly at a considerable distance from another larva. They were less active when disturbed than larvae of the fruittree leafroller. Green fruitworm larvae are light green with longitudinal white lines along the dorsum (Fig. 1), and when mature are robust and 3-4 cm long.

Field collected larvae were brought into the laboratory and caged on excised apple leaves and on potted apple seedlings. Larval mortality was high, and only a few reached maturity. Mature larvae dropped to the soil, burrowed about an inch below the surface and pupated. Soil containing the pupae was placed outside in

[1] Contribution No. 338, Research Station, Summerland.

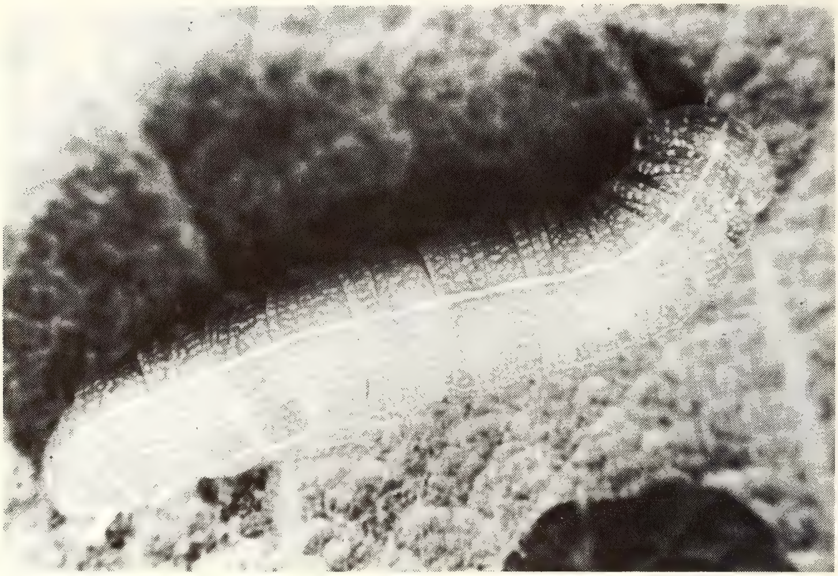

Fig. 1. Mature larva of **Lithophane georgii.**

a screenhouse, and moths emerged in October. They were typical noctuid moths, thick bodied with gray wings. These laboratory reared specimens were collected and submitted for identification.

Moth emergence in October indicates that the species overwinters as an adult which seems an unusual behavior in the cold winters of inland British Columbia. Rings (1969) reported that a related species, *Lithophane laticinerea* Grote, overwinters in Ohio as an adult and deposits eggs the following March and April.

To determine if adults were active in early spring, 2 standard 15 watt ultraviolet light traps were installed in an apple orchard at Kelowna in March. Cheesecloth bags were fitted to the base of the traps in order to collect live moths. Several male and female *L. georgii* were captured in March and early April. They were placed in cloth sleeve cages on tree limbs in the hope that mating and oviposition would occur. No eggs were laid on the leaves, blossoms or bark of the caged limbs. Branch samples were collected at random from this orchard and examined in the laboratory, but eggs were not found on these samples. Moths of *L. georgii* are evidently active early in the season, but the location and distribution of eggs is still unknown.

Very few *L. georgii* larvae were found during the 1971 season in either commercial or abandoned orchards. The species may exist in low numbers naturally, or unknown factors may influence their abundance from season to season. It is evident from field observations made during the last two seasons that damage caused by the fruittree leafroller is difficult to distinguish from that caused by the green fruitworm. Probably, a portion of the injury caused by fruittree leafroller has been incorrectly identified as green fruitworm damage.

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SEASONAL HISTORY OF THE BALSAM WOOLLY APHID IN COASTAL BRITISH COLUMBIA[1]

L. H. MCMULLEN AND J. P. SKOVSGAARD

ABSTRACT

Studies of the balsam woolly aphid at four locations in south-western British Columbia showed that there were basically two generations per year, although only a partial second generation may occur at high elevations and a partial third generation at low elevations in some years. The initiation of spring development occurred as early as February in the moderate climatic sites and as late as May in the more severe ones. The first crawlers appeared in late April, with initial peak abundance occurring from late May to the first half of July, depending on location. Thereafter crawlers were present during the remainder of the season, even into December at low elevations, with peaks in abundance occurring throughout August, September and October.

INTRODUCTION

The balsam woolly aphid, *Adelges piceae* (Ratzeburg), a native of European white fir (*Abies alba* Miller), is capable of attacking all true firs (*Abies* spp.). It has been introduced to both coasts of North America, probably through movement of nursery stock (Balch, 1952).

The insect was first found in British Columbia in 1958 (Silver and Ross, 1959) and is presently distributed over 3700 square miles of the southwestern mainland and Vancouver Island (Molnar *et al.*, 1970). Amabilis fir (*Abies amabilis* (Douglas) Forbes) has suffered heavy mortality, and grand fir (*A. grandis* (Douglas) Lindley), although more resistant to injury by the insect, has suffered appreciable mortality and deformity. Alpine fir (*A. lasiocarpa* (Hooker) Nuttall) also suffers heavy mortality but the insect is not widely distributed in stands of this species. Further spread of the aphid threatens the alpine fir stands in the interior of the province and amabilis fir stands on the coast and Vancouver Island.

A knowledge of the seasonal history is important in assessing the hazard of further spread. The aphid is a minute, parthenogenetic insect, the life cycle consisting of five stages: egg, first-instar nymph (which includes an active crawler and a settled "neosistens"), second- and third- instar nymphs and adult. Winged forms seldom occur and the only motile stage is the crawler. The aphid usually overwinters in the neosistens stage. The number of generations per year varies with climatic conditions. In Eastern Canada, one generation occurs in cool regions and a second and partial third in warmer regions (Greenbank, 1970). In western United States, up to four generations occur in mild climates at low elevations (Tunnock and Rudinsky, 1959; Mitchell *et al.*, 1961).

Studies of the seasonal history of the balsam woolly aphid were carried out in British Columbia during 1967 and 1968 to determine the number of generations per year, the time of initiation of development in the spring, and the time of year when crawlers were most abundant.

METHODS

Four study sites were located in infested stands of *A. grandis* and *A. amabilis*. The former stands were on Vancouver Island near Victoria (elev 100 ft) and Deerholme (elev 300 ft), near Duncan; the latter were on the lower mainland in the Seymour Valley (elev 800 ft) and on Mount Fromme (elev 2700 ft), both near North Vancouver. Seasonal history was determined by weekly examination of infested stems and tanglefoot[2]covered cards. The trees selected for study varied from 12 to 20 inches dbh, had medium to heavy stem populations, and were located near the stand margins.

Study areas, on the bark were examined with a stereo microscope (approx. 20X) (Fig. 1). Light was provided by a microscope lamp, fitted with a heat absorbing lens, and powered by a small six-volt battery.

On amabilis fir, the study areas (7 to 10 on 3 trees at each location) were 1-inch squares of bark, delineated by red wax pencil and divided into quarters. A dot in the centre of each quarter facilitated orientation and "mapping" the location of aphids. On grand fir, the rough bark made this method unsatisfactory. Instead,

[1]Contribution from Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B.C.

2 Tree Tanglefoot Ltd., Grand Rapids, Michigan.

Fig. 1. Examination of bole with microscope mounted on scissor jack on portable platform and showing tanglefoot drop cards (arrows) in position on the bole.

the field of view of the stereo microscope (approx. 0.1 sq inch) was used and map pins on the bark located the positions (6 to 12 on 3 or 4 trees). The stage of development of each aphid was recorded weekly on a map of the study area.

The tanglefoot-covered cards (Fig. 2) were mounted on three or four trees at each site. Each card was supported by galvanized metal of the same size and placed in a horizontal slit cut in the bark of the tree, one at each cardinal direction (Fig. 1). The cards were replaced weekly and examined for numbers of crawlers (crawler drop). Sub-blocks marked on the

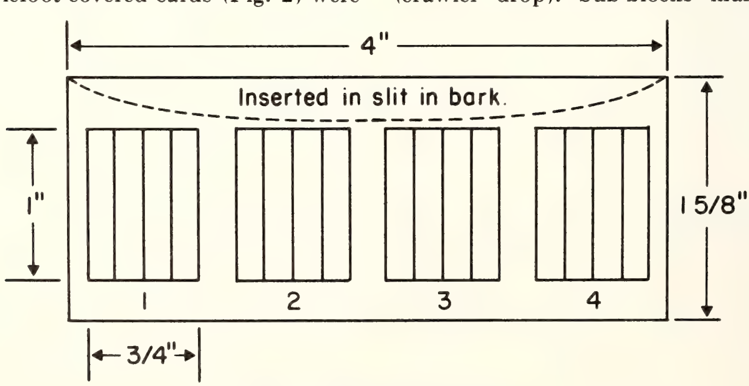

Fig. 2. Crawler drop card.

cards facilitated counting the number of crawlers in each block; when numbers were extremely high, totals for each card were estimated from counts in one sub-block chosen at random in each of the blocks.

Temperature records were obtained from hygrothermographs operated in the stands throughout the year at Deerholme and Victoria, and from mid-April (1 June, Mt. Fromme, 1967) to mid-November on the lower mainland. The thermograph records were supplemented with data from federal government weather stations. Degree-days above 42° F were calculated from the maximum and minimum temperatures (no upper threshold) (Baskerville and Emin, 1969). As a check on this technique, degree-days were also calculated for 2 one-week periods each year at each location by measuring the area above 42°F and below the trace on the thermograph charts. Although the latter were usually slightly higher, particularly at Victoria and Deerholme, differences for the total of the 4 one-week periods at any one location did not exceed 5.3% .

RESULTS AND DISCUSSION

A total of 3425 neosistentes were examined on the boles; 825 in the spring, 1548 in the summer and 1052 overwintering in the fall; 888 adults were observed. Duration of the immature stages showed no consistent differences associated with location and are grouped in Table I. However, those individuals that moulted to second instar early in the spring took longer to develop.

TABLE 1. Duration (weeks) of immature stages of balsam woolly aphid.

Season	Instar								
	1			2			3		
	n[1/]	Mean	se[2/]	n	Mean	se	n	Mean	se
Spring	Overwinter			328	2.9	0.09	338	2.2	0.06
Summer	558	5.9	0.11	445	1.1	0.03	309	1.1	0.06

1/ Number of individuals
2/ Standard error

The insect's seasonal history for each location and year, as determined from bark observations, is shown in Figure 3. The major difference among locations was the late initiation of spring development on the lower mainland, particularly on Mount Fromme. Between years, the major difference was the earlier appearance of adults in the spring and earlier settling of overwintering neosistentes in the fall of 1968. Although only immature stages were present on the study areas, on Vancouver Island during January, February and March, occasional adults with eggs were seen on other areas of the bole.

Crawler drop for both years at each location is shown in Figure 4. In 1967, the cards were not in place early enough to observe initiation of crawler drop except on Mount Fromme, where it occurred on 12 June. Although a few crawlers were found on the cards during February, March and April in 1968 on Vancouver Island, a major increase in numbers did not occur until mid-May. Crawlers were first found in Seymour Valley on 23 May and on Mount Fromme on 5 June.

The peaks in crawler drop (Fig. 4) indicate periods of greatest crawler abundance, with the initial peak representing progeny of the overwintering generation. Following this peak, crawlers were present continuously, with populations peaking at various times, until December. The major differences among locations were the later occurrence of the initial peak on the mainland and the lack of a second peak on Mount Fromme in 1968. The initial peak crawler drop occurred slightly earlier in 1968 than in 1967 at Victoria, whereas it occurred earlier in 1967 at Seymour. At Deerholme and Fromme this peak occurred at about the same time in both years.

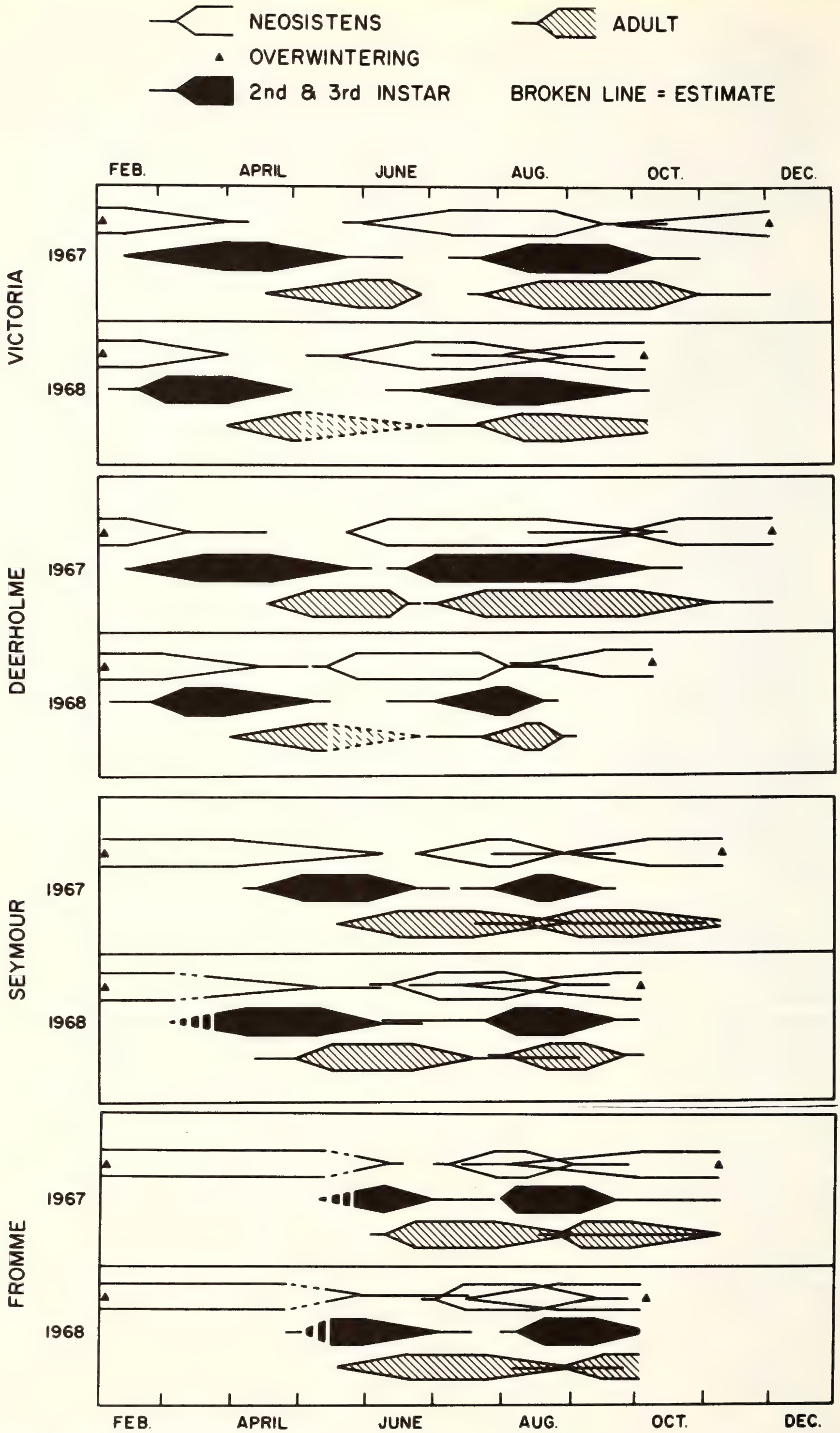

Fig. 3. Seasonal development of balsam woolly aphid on the bole at four locations, 1967 and 1968. The wide part of each bar represents the period when over 80%, and the single line less than 20%, of the maximum population of that stage was present.

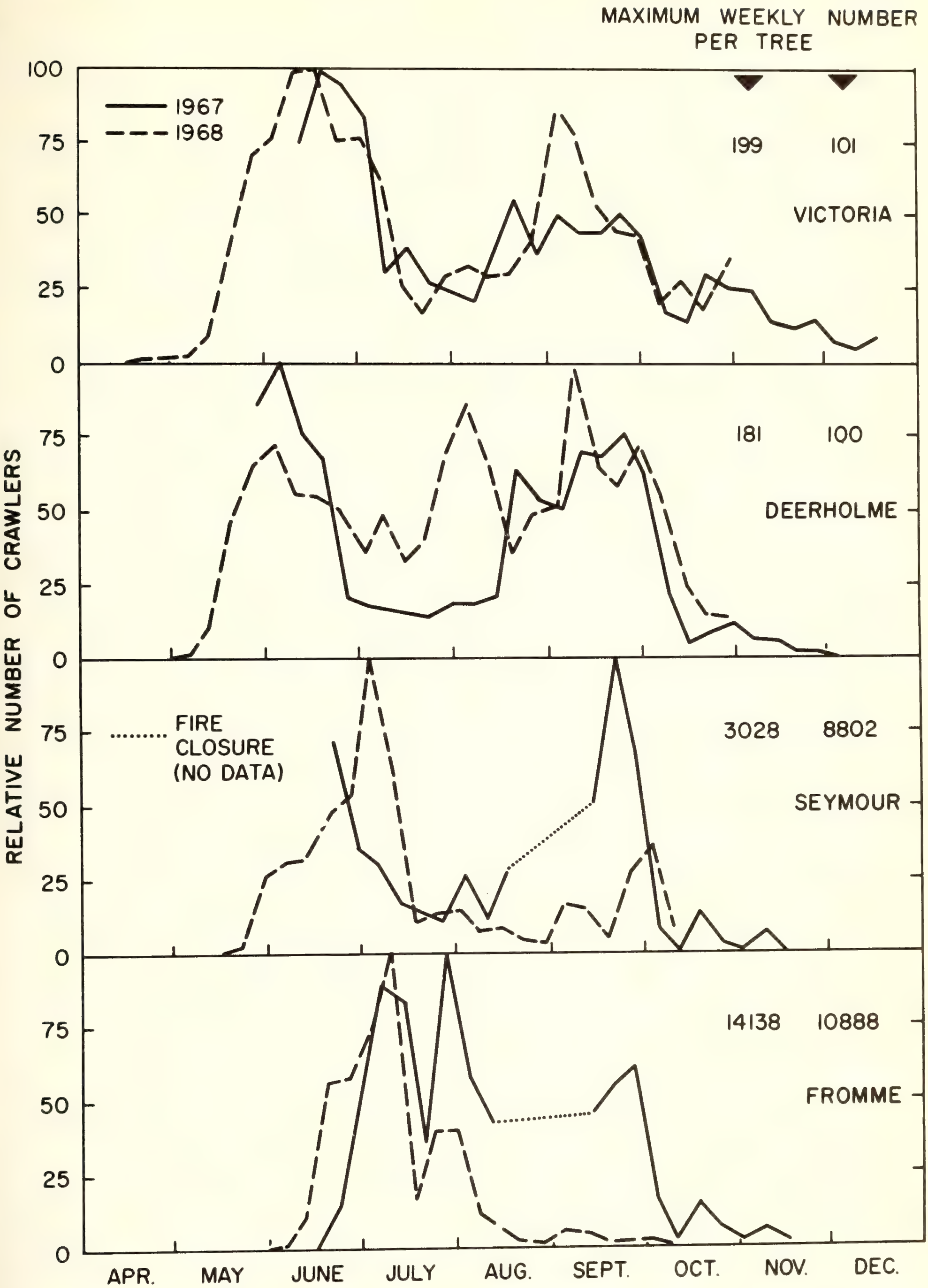

Fig. 4. Crawler drop relative to maximum weekly number (expressed as 100) at four locations, 1967 and 1968.

Greenbank (1970) indicated that 650 degree-days above 42 F were required for completion of the overwintering generation and an additional 1550 were required for completion of a second generation in New Brunswick. The dates on which these requirements were met at each location in each year (Table II) indicate that at least two

TABLE II. Dates on which heat accumulations of 650 and 2200 degree-days above 42°F were attained at four locations in 1967 and 1968.

Location	Degree-days			
	650		2200	
	1967	1968	1967	1968
Victoria	June 7	May 23	August 20	August 15
Deerholme	June 12	June 11	August 25	September 10
Seymour	June 17	June 20	August 24	September 7
Fromme	July 2	July 10	October 9	(Oct. 7 only 1590)

generations might be expected at all locations except Mount Fromme in 1968, and that development would be later on the mainland than on Vancouver Island. Although heat accumulation requirements were met earlier at Victoria than at Deerholme, the bole examinations and crawler drop indicated that development of the overwintering generation occurred at least as rapidly at Deerholme as at Victoria. Although mean temperatures were usually slightly lower at Deerholme than at Victoria, maximum temperatures were higher, suggesting that more efficient development took place under conditions occurring at Deerholme.

The crawler drop was affected to some extent by weather conditions, as indicated by the means of the daily maximum temperatures (mean maximum temperature) during the periods of crawler drop (e.g. Seymour Valley, 1968, Fig. 5). Higher temperatures cause greater activity of the crawlers (Atkins and Hall, 1969) and therefore increase the chance of their dropping onto cards. Initial peak crawler drop was possibly delayed at Seymour in 1968 by early June weather conditions.

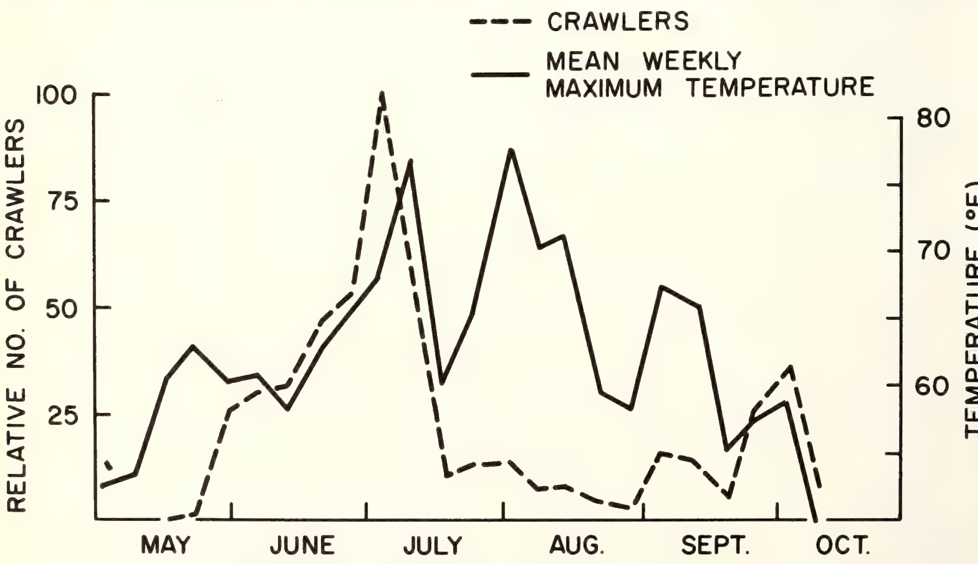

Fig. 5. Crawler drop and mean maximum temperatures in Seymour Valley, 1968.

Variation in crawler drop was also introduced by differences in trees. The initial peak crawler drop on different trees at the same location was up to two weeks apart, and later peaks up to five weeks apart. The pattern of crawler drop on one tree at Deerholme (Fig. 6) was greatly different from the pattern on other trees in 1967 and was omitted from the data for Figure 4. Although the initial peak occurred at the same time as on other trees, the second peak occurred only five weeks later, whereas at least eight weeks elapsed between similar peaks on other trees at all locations. The pattern of drop was similar on each cardinal direction and no differences in location of this tree in comparison with other trees at Deerholme were apparent. Some individual host difference may have promoted rapid development of the summer generation on this tree. In 1968, such extreme differences between this tree and others were not apparent, although peak populations of crawlers did differ in relative magnitude. Unfortunately, the development of the aphid on the bole of this tree was not observed.

Comparison of monthly mean temperatures, 1955 through 1969, at Victoria Gonzales and Vancouver Airport weather stations indicated that neither 1967 nor 1968 had extreme weather conditions except that February-March 1968 was one of the warmest of the 15 years. Thus 1967 and 1968 were fairly representative years. However, the warmer spring weather in 1968 was reflected by the earlier appearance of adults on the bole in the spring of that year (Fig. 3). August and September weather conditions, being cooler in 1968 than in 1969, probably delayed development of many neosistentes, and accounted for the earlier settling of those that eventually overwintered (Fig. 3).

In general, two generations occurred each year, although crawler drop records for Mount Fromme exhibited little evidence of a second generation in 1968. However, bole examinations indicated that a portion of the population completed a second generation while the rest remained in the neosistens stage and eventually overwintered. Bole observations could not separate additional generations occurring during the summer, since the parents of newly settled neosistentes could not be determined. However, evidence indicates that a third generation occurred on Vancouver Island. The crawler drop for both Victoria and Deerholme showed at least two distinct peaks, and crawlers were present thoughout November in 1967 and were still numerous in October, 1968, when observations ceased. Furthermore, the average duration of various stages (Table I) indicated that third generation adults could appear by mid-September at both Victoria and Deerholme and heat accumulation (Table II) at Victoria was sufficient by late August in both years for completion of a second generation, leaving the remainder of the season for at least a partial third generation.

The effect of partial generations on populations is open to conjecture. That portion

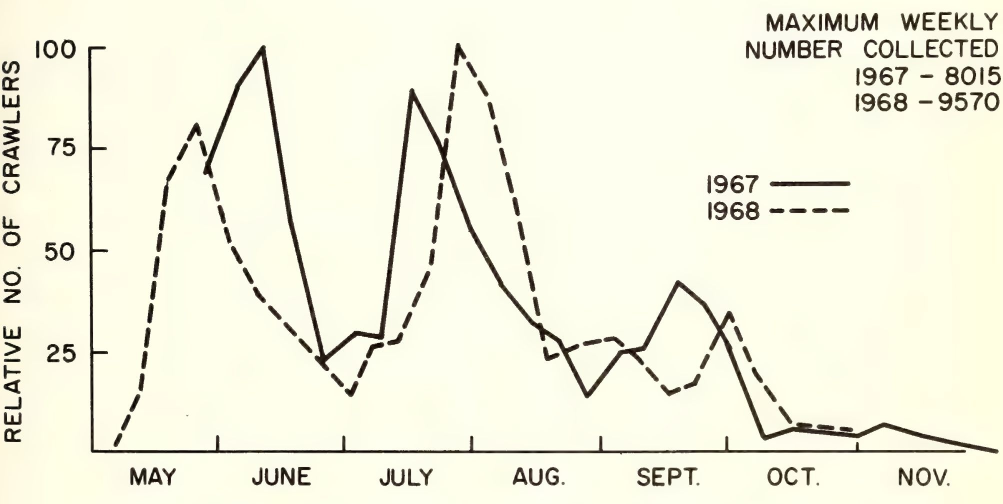

Fig. 6. Atypical crawler drop from the bole of one tree, Deerholme, 1967 and 1968.

of the population unable to attain the normal overwintering neosistens stage could be expected to suffer high mortality, expecially under severe climatic conditions. Greenbank (1970) provides an example in which 6% of the population formed a partial third generation and increased the overwintering population by 25%.

The different host species, grand and amabilis fir, may have contributed to differences between the mainland and Vancouver Island. However, weather conditions appeared to be the dominating factor.

Dispersal of the insect is believed to be chiefly by wind (Balch, 1952), but it may be spread by man (Atkins and Woods, 1968). Thus the main hazard of dispersal exists when the crawlers are present, from late April through November, although peak crawler populations occur at various times. At high elevations, the major hazard period is reduced to June through October.

The results of the studies reported here provide a guide to the times of year when various stages of the insect are present, and confirm that heat accumulation data can be used as a general guide to the number of generations. However, variations are such that when precise knowledge is required, sampling of the populations would be necessary.

Acknowledgements

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FLIGHT-MUSCLE DEGENERATION IN SPRUCE BEETLES, *DENDROCTONUS RUFIPENNIS* (COLEOPTERA:SCOLYTIDAE)

T. G. Gray and E. D. A. Dyer[1]

ABSTRACT

Changes in width of an indirect flight muscle, the lateralis medius, were measured at various stages of adult life of **D. rufipennis.** This muscle degenerated in both female and male spruce beetles after flight and attack on the host. Flight muscles of young adults that emerged in late summer to enter hibernation were smaller than those of beetles taken in spring flight. Young beetles entering hibernation did not disperse by flying, but dropped or crawled to the bases of trees, in which they had developed, and burrowed into the bark.

INTRODUCTION

Spruce beetles, *Dendroctonus rufipennis* Kirby, like other *Dendroctonus*, accomplish flight to new hosts, attack and egg-laying during one summer. Sometimes there is a second attack by parent adults during this season. Unlike most *Dendroctonus*, spruce beetles usually take two years to develop, overwintering the first year as larvae, pupating in June and becoming young adults in July. However, these beetles differ from all other *Dendroctonus* in that many young adults abandon the galleries in which they develop and fall or crawl to the tree base, where they re-enter the bark to hibernate (Massey and Wygant, 1954). Knowledge of flight-muscle change and flight capability is important in interpreting what beetles do after emergence from the host.

Flight-muscle changes during brood establishment have been observed in the Scolytidae (Chapman, 1956; Reid, 1958) and gross flight-muscle changes have been reported in *Dendroctonus* (Chapman, 1957; Reid, 1958; Atkins and Farris, 1958; McCambridge and Mata, 1969). Detailed studies of these changes were made by Atkins and Farris (1962) on *Dendroctonus pseudotsugae* Hopkins and on *Ips confusus* Le Conte by Bhakthan, Borden and Nair (1970) and Bhakthan, Nair and Borden (1971). Chapman (1956) suggested that atrophy and regeneration of flight muscles influence Scolytid behavior because beetles cannot fly from their galleries during brood production. The present studies were conducted to measure flight-muscle change in spruce beetles after host attack and to determine whether young beetles, emerging for the first time in August and September, were capable of flight.

METHODS AND MATERIALS

Adults were collected in two widely separated regions of British Columbia; Lodgepole Creek, near Fernie and the Naver forest, near Prince George. These beetles had overwintered and were capable of flight. Some were allowed to infest freshly cut billets and were later excavated in the boring, egg-laying or post egg-laying stages. Young adults, emerging in late summer from infested spruce trees, *Picea engelmannii* Parry and *P. glauca* (Moench) Voss, were captured by screen enclosures (Massey and Wygant, 1954). After collection, beetles were fixed and retained in alcoholic Bouin's until dissection.

The left and right lateralis medii muscles were removed and placed in 70 ethanol for measuring. Measurements were made to the nearest micron, using a dissecting microscope with ocular micrometer. The width (Fig. 1) was recorded at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the muscle length. To compensate for the effect of body size on muscle size, comparisons were made, using a median size index calculated by dividing the average of the three widths by the width of the beetle's pronotum and taking the average for the left and right muscles (McCambridge and Mata, 1969).

RESULTS AND DISCUSSION

The lateralis medii are indirect flight muscles, attaching on the metacoxa and inserting on the prescutal and scutal lobes (Fig. 1). These dorsoventral muscles, rather than the longitudinal extensor muscles, were chosen as indicators of flight-muscle degeneration because the former exhibited greater change in size. The muscle's width was more indicative of atrophy than thickness because the lateralis

[1]Pacific Forest Research Centre, Victoria, B.C.

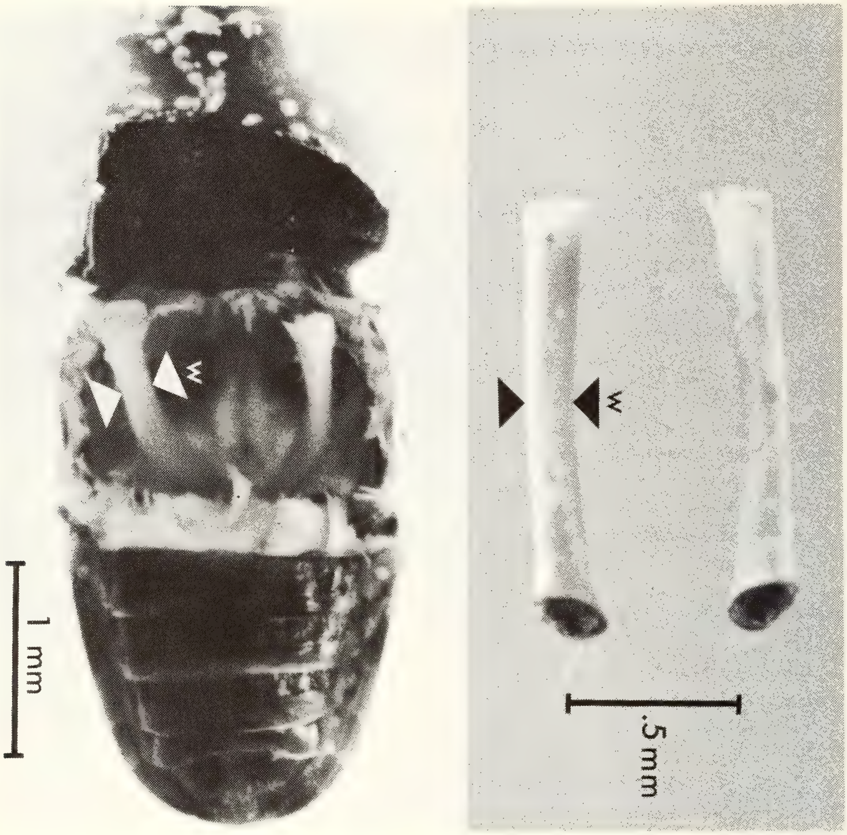

Fig. 1. Indirect flight muscles lateralis medius in adult **Dendroctonus rufipennis.** Arrows denote width (w).

medius became compressed transversely into ribbon-like tissue during egg-laying.

The muscle median size indices for female beetles (Table 1) show a progressive reduction in width from the flight-capable condition through initial boring under the bark to egg-laying. This change occurred in beetles from both areas. The gradual reduction in muscle size is similar to that reported by McCambridge and Mata (1969) for laboratory-reared *D. ponderosae.*

Male spruce beetles, from the same galleries as the females, revealed a similar pattern of muscle change, but more degeneration. However, variation in muscle size was greater in males and fewer of them were collected at the various stages. Atkins (1959) found that, during brood establishment, the sex ratio of parent *D. pseudotsugae* changed in favor of females because some males remained flight-positive and left the galleries early.

The young spruce beetle adults emerging to hibernate had underdeveloped wing muscles, apparently incapable of sustaining flight (Table 1). Approximately one-third of the beetles were flight tested prior to measurement and when tossed, none flew or opened their elytra, as do those capable of flight. Beetles were classified as emerging-to-hibernate because, at that time, beetles from unscreened parts of the same trees were crawling down and re-entering the bark near ground level. Others taken under similar conditions in previous years, hibernated and would not establish brood galleries in freshly cut billets, a behavior reported by Massey and Wygant (1954).

Because young beetles emerging to hibernate have underdeveloped wing muscles, they are unable to disperse by flight or reach new hosts. They crawl or fall to the tree base to re-enter and pass the winter. Emergence without flight capability may have advantages

TABLE I. The median size index of the lateralis medius of female spruce beetles collected from two areas of British Columbia.

Stage of adult beetle life	Median Size Index					
	Lodgepole			Naver		
	No. of beetles	Mean	S.D.	No. of beetles	Mean	S.D.
Pre-flight	13	0.157	0.007	9	0.153	0.014
Flight	22	0.155	0.019	11	0.160	0.013
Boring	6	0.113[a]	0.003	25	0.117[a]	0.036
Egg-laying	11	0.069[a]	0.022	26	0.072[a]	0.038
Post egg-laying	11	0.067[a]	0.025	-	-	-
Emerging to hibernate	24	0.087[a]	0.025	-	-	-

[a] Means within columns differed significantly (t .01) from the flight condition.

for survival. Beetles that cannot fly to hibernate in autumn do not undergo the risks inherent in an extra flight or use energy needed for hibernation and flight the next spring. The tree-base hibernating site has the advantage of being in the thickest bark and being covered with snow most of the winter. This provides protection from extreme cold, and from winter woodpecker predation which occurs on the tree bole but not at the base.

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CORIXIDAE (HEMIPTERA) AS PREDATORS: REARING ON FROZEN BRINE SHRIMP

A. JANSSON AND G. G. E. SCUDDER[1]

ABSTRACT

Many Corixidae are predaceous. In the laboratory they can be reared on frozen brine shrimp. Feeding seems not to occur when temperatures are as low as 5°C.

The water boatmen or Corixidae, although members of the Hemiptera, lack a distinct beak or rostrum, the labium being reduced to a short triangular flap with a mid-dorsal median longitudinal groove (Benwitz, 1956; Parsons, 1966). However, they do have stylets and so they have been presumed to feed like other members of the Order. Feeding as they do on a liquid diet, the Hemiptera usually lack a peritrophic membrane, but Sutton (1951) believes that the membrane is present in Corixidae, although this has not been proven (Parsons, 1957). Significantly, these water-bugs also have a complex of buccopharyngeal teeth that would appear to be useful for masticating solid food and passing it along the gut (Slack, 1947; Elliott & Elliott, 1967).

Hungerford (1919) noted that the Corixidae gather their food by sweeping flocculent material into the mouth with their fore tarsi (palae). This material consists of algae, protozoa and various microscopic metazoa and the bugs were presumed to utilize it as food. They also were reported by Hungerford (1919) to feed on algal filaments by piercing each cell with their protrusible stylets and sucking out the contents. In general, the Corixidae were regarded as feeding largely on detritus or algae (e.g. Popham, 1959). Mellanby (1951) stated that they do not pierce with their mouth parts to obtain food, but suck up particles of debris using the short proboscis like a vacuum cleaner. Puchkova (1969) noted that *Sigara striata* (L.) and other Corixidae have a mixed type of feeding, with a predominance of phytophagy.

During a study of the Corixidae in a series of saline lakes in central British Columbia (Scudder, 1969a, 1969b), it was found that in the more saline lakes *Cenocorixa bifida hungerfordi* Lansbury and *C. expleta* (Uhler) fed almost exclusively on Diaptomids (*Diaptomus nevadensis* Light and *D. sicilis* Forbes) in the zooplankton. In the laboratory, Scudder (1966) reared both species of *Cenocorixa* on living brine shrimp (*Artemia salina* L.) and in recent research (Jansson, 1971) all species of *Cenocorixa*, as well as members of other genera, were successfully reared through several generations on frozen brine shrimp.

Zwart (1965) investigated the effect of different types of food on the survival of several European Corixids and found that both adults and larvae survived longest when fed on animal food, such as *Tubifex*, daphnids and chironomid larvae. Experiments carried out by us in the past few years support this conclusion. Whether these results will apply to all genera and species of Corixidae has not yet been determined. Sutton (1951) showed that species of *Corixa* and *Sigara* would feed on chironomid larvae, mayfly naiads, daphnids, *Asellus* and *Tubifex;* and James (1966) recorded *Callicorixa audeni* Hung. as feeding on mosquito larvae in southern Ontario. Jansson (1969) has reared all North European species of *Sigara*, *Arctocorisa* and *Callicorixa* on Enchytraeid worms that were cut into 1-2 mm. pieces before placing into the corixid containers (if the worms were not cut up they escaped into detritus before the bugs could find them). Also, Jansson (unpublished) observed *Cymatia* and *Glaenocorisa* to catch and feed on mosquito larvae, but found that while *Sigara alternata* (Say) will feed on frozen brine shrimp, it will not reproduce on this diet, although it was observed to reproduce after a week on a diet of freshly killed mayfly naiads. It becomes clear that the Corixidae should no longer be regarded as mainly algae and detritus feeders.

Zwart (1965) considered that feeding on dead animal food caused high mortality in adult *Corixa punctata* (Ill.) and *Sigara distincta* (Fieb.), but he noted that this mortality resulted from the unfavourable

[1] Department of Zoology, University of British Columbia, Vancouver, B.C.

conditions created by the dead and decaying chironomids, etc. that occurred from supplying the bugs with surplus food. Our experiments demonstrated that for successful rearing on frozen brine shrimp, it was important to keep the tanks containing Corixidae well aerated in order to avoid putrefaction of excess food and the resulting contamination of the water: Zwart (1965) did not record whether his cultures were well aerated. We found that by providing sufficient but not undue excess of frozen brine shrimp, and at the same time keeping the water well aerated by use of air-stones run off a laboratory air supply, we could rear most species of Corixidae at 15 to 25° C with very little mortality. We also noted that species of *Cenocorixa* did not appear to feed in the laboratory at 5° C.

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INDUSTRIAL MELANISM: A POSSIBILITY IN BRITISH COLUMBIA

G. G. E. SCUDDER[1]

ABSTRACT

Melanics of the Geometrid **Biston cognataria** Guenée have been recorded from the comparatively polluted Vancouver area of British Columbia. At present the genetic basis and evolutionary significance of this is unknown.

Industrial melanism has been studied extensively in the British Isles and Europe (Ford, 1945; Kettlewell, 1955a, 1955b, 1955c, 1956a, 1956b, 1958a, 1958b, 1961, 1965a; Clarke & Sheppard, 1963, 1966; Bishop & Harper, 1970; Cook *et al.*, 1970; Askew *et al.*, 1971) where the Geometrid *Biston betularia* (L.) occurs predominantly as the black form *(carbonaria)* in polluted industrialized areas, but is much less common in or absent from non-polluted agricultural or rural areas. Experiments by Kettlewell (1955b, 1956b) and Clarke & Sheppard (1966) have shown that there is differential survival of the morphs in different areas, bird predators preferentially selecting the form that does not match the background. Thus, in industrial areas where the lichen on tree trunks has been killed, the tree trunks are rather uniform black and hence melanic forms resting on such trunks in the daytime are not readily seen by predators, whereas normal pale forms are easily detected and preyed upon. In non-polluted aras, the tree trunks are covered with lichen and the normal forms are cryptically coloured and hence overlooked, whereas melanic forms are obvious to bird predators.

Kettlewell *(loc. cit.)* has demonstrated that the frequency of the melanic form can be correlated with the occurrence and intensity of industrial pollution. Further, recent work in England has also shown that in the Manchester and Liverpool areas, there has been an increase in the frequency of the typical pale form of *B. betularia* during the last decade, and this seems to correlate with the decrease in atmospheric pollution as a result of smoke control and the introduction of smokeless zones (Clarke & Sheppard, 1966; Cook *et al.*, 1970; Askew *et al.*, 1971).

In North America industrial melanism is also reported in *Biston cognataria* Guenée (Kettlewell, 1958b, 1961; Owen, 1961, 1962), and since this will interbreed with *B. betularia* (Kettlewell, 1965b), the two taxa may be conspecific. Owen (1961) notes that the melanic form of *B. cognataria* is common in the eastern part of North America, being reported in southeastern Pennsylvania as early as 1906 and the Pittsburg area in 1910; the earliest records for the Chicago area were in 1935 and for the Long Island region in 1954. In Washtenaw County, Michigan, Owen (1961) records the melanic of *B. cognataria* as having constituted 96.7 per cent of the population in 1959.

B. cognataria as a larva feeds on the leaves of many broad-leaved trees, and occurs from Nova Scotia and the Mattaganii River in the north, to New Jersey and Pennsylvania in the south, and reaches from California and Oregon to British Columbia in the west. It also occurs in the eastern Palaearctic from northern India to Japan. Owen (1961) reports that the melanic form is not known to occur in China and Japan, and no records of the melanic form are available from the western U.S.A. Dr. W C. McGuffin informs me *(in litt.)* that in Canada the melanic form is known only from southern Ontario and the eastern township of Ste. Clothilde in Quebec.

Recently, I have come across two melanic specimens of *B. cognataria* in the collections of the University of British Columbia. Both specimens were taken on August 8, 1957 in Vancouver by the late Prof. G. J. Spencer; normal pale specimens were also taken at the same time. Within the last few years, additional melanic specimens have been taken in the lower mainland of the province by Mr. John Gordon. Unfortunately, light traps have not been run in a continuous manner in the region. It is thus not known if the melanic form occurs in appreciable numbers at the present time. Nevertheless, it is of interest to report that I have not taken the melanic form of this moth in light traps run at various times at Westwick Lake, near Williams Lake in the interior Cariboo region of British Columbia. Williams Lake is 200 airmiles north of Vancouver. In these traps, run during the summer in the years 1964 to 1970, no melanics were

[1] Department of Zoology, University of British Columbia, Vancouver 8, B.C.

captured, but the normal pale form was taken commonly. At Westwick Lake there is virtually no industrial pollution.

Our future research will determine the present proportions of the melanic form of *B. cognataria* in populations in the Greater Vancouver area and lower mainland. It is certain that industrial pollution in the region is relatively high, especially in the New Westminster area. Thus, one may suspect that pollution in the Vancouver area in 1957 and since, has been high enough to lead to natural selection favouring the melanic form of this moth, in much the way that it has in Europe and eastern North America. However, it should be stressed that melanism may arise from time to time for very different reasons, aerial crypsis and heat absorption being two such possibilities.

Klots (1964, 1966, 1968a, 1968b) has reported melanism in a number of moths in Connecticut and considers that here the melanism is not related to industrial pollution, but perhaps to darker environments brought about by reforestation. In *Phigalia titea* (Cramer), Sargent (1971) suggests that the melanics that occur in rural areas may have a physiological superiority over the normal pale form, effects of industrialization other than environmental darkening perhaps being involved. Further, the melanics reported in Shetland by Kettlewell & Berry (1961, 1969) seem also not related to industrial pollution. Nevertheless, in *B. betularia* and *B. cognataria* observations to date suggest strongly that melanism in these taxa is usually associated with industrial pollution in some form or another.

Kettlewell (1961) has noted that while industrial melanism and relict or geographic melanism is usually inherited as Mendelian dominants, semilethal melanics can also occur as rarities, possibly at about mutation-rate in certain species, and in these the method of inheritance is recessive. Thus, it is important to determine the frequency of melanics in *B. cognataria* in the Vancouver area, and imperative to breed these forms so as to determine the genetic basis of the black coloration.

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METRIC CONVERSION

Contributors of papers on laboratory studies should use the metric system exclusively. Use of the metric system in reporting the results of field studies is a desirable ultimate objective. Since it is difficult to replace immediately such standard concepts as lb/acre by the unit kg/hectare, yards by meters, or miles by kilometers, the following table of conversion factors is presented.

1 in.=2.54 cm	1 ft^3=28.3 dm^3	1 cm=0.394 in
1 yard=0.914 m	1 acre=0.405 hectares	1 m=3.28 ft=1.094 yards
1 mile=1.61 km	1 lb/acre=1.12 kg/hectare	1 km=0.621 mile
1 lb.=453.6 g	1 lb/in^2(psi)=70.3 g/cm^2	1 kg=2.2 lb
1 gal (U.S.)=3.785 liters	1 lb/gal (U.S.)=120 g/liter	1 liter=0.264 gal (U.S.)
1 gal (Imp)=4.546 liters	1 lb/gal (Imp)=100 g/liter	1 liter=0.220 (Imp)

1 dm^3=0.0353 ft^3
1 hectare=2.47 acres
1 kg/hectare=0.89 lb/acre
1 g/m^2=0.0142 psi
1 g/liter=0.83 lb/100 gal (U.S.)
=1000 ppm
1 g/liter=1 lb/100 gal (Imp)

A EUROPEAN STAPHYLINID BEETLE FROM THE PACIFIC NORTHWEST, NEW TO NORTH AMERICA[1]

VOLKER PUTHZ[2]

In his book, "Faunal Connections between Europe and North America," Lindroth (1957) gives an account of the known animal species common to the two continents and explains in detail the ways of dispersion in both directions (see also Strauch, 1970). Many of these species were introduced from Europe to North America in the ballast of sailing vessels in the North Atlantic trade. The ballast was dumped at those localities where these ships loaded cargo for shipment to Europe.

While studying the Steninae of the world I have found two species of the genus *Stenus* Latr. which have been introduced from Europe to North America: *Stenus melanopus* (Marsh.) and *Stenus fulvicornis* Steph. *S. melanopus* is known only from one specimen taken at Seneca Lake, N.Y. by Dr. Lenczy in 1965, and now in the Budapest Museum (Puthz, 1966:146). *S. fulvicornis* was sent to me by Dr. Lazorko of Vancouver, B.C., who found it at Essondale, about 20 km E of Vancouver. Dr. Lazorko informs me (*in litt.*) that for some years he has regularly found this species at Essondale, although it is not common there. Specimens were found in autumn creeping on the walls of the Essondale hospital (23.X.62, 13.IX.66, 28.XII.67, 28.VIII.68), and others were captured by sifting debris near a creek or in a forest in springtime (12.IV.65, 6.V.65, 3.VI.66, II.V.68). A considerable number of introduced European beetles occur near Essondale, nearly all of which seem to have been introduced in ballast.

Scudder (1958) shows that "Departure Bay, just north of Nanaimo on Vancouver Island, was a centre for ballast dumping." He also points out, that "most of the European insects introduced into the Pacific Northwest have been late arrivals compared with eastern Canada." The recent findings of *Stenus fulvicornis* Steph. agree with this statement. It is highly improbable that this species has been overlooked by collectors in the last century or in the first decades of the present century. *S. fulvicornis* must be a late introduction with ballast from southwestern England, where it lives in places from which ballast was often taken (Lindroth, 1957:187).

Identification of *S. fulvicornis* is easy because it is totally different from the other nearctic *Stenus* which have the abdomen immargined and the tarsi bilobed ("*Hypostenus*"). The species is characterized by the following characters: 10th tergite equally rounded, with no median tip or apical anchor, head narrower than elytra (the species is macropterous), legs reddish-yellow, interstices of elytral punctation lacking reticulation, aedeagus (Wusthoff, 1934, fig. 67) with the median lobe triangularly narrowed into an acute apex, distinctly shorter than the parameres. Length: 3.3 to 3.8 mm. In the palearctic region *S. fulvicornis* is known from Europe s.l. including the Mediterranean.

[1]124th contribution to the knowledge of Steninae.

[2]Limnologische Fluss-Station des Max-Planck-Instituts fur Limnologie, Schlitz/Hessen, Germany.

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LARVAL DIAPAUSE IN *SCOLYTUS VENTRALIS* (COLEOPTERA: SCOLYTIDAE)[1]

B. A. SCOTT, JR. AND A. A. BERRYMAN[2]

ABSTRACT

When **Scolytus ventralis** was reared under relatively constant temperatures 50-70% of the brood developed rapidly and emerged within 70 days. The remainder emerged gradually over the 130 days following the first emergence peak. Exposure to field conditions resulted in retarded emergence of the rapidly-developing proportion of the population and increased synchrony in the emergence pattern. Increasing exposures to cold temperatures in the field resulted in increased emergence synchrony, and a shorter developmental time when exposed to warmer temperatures in the laboratory. It was concluded that the rapidly-developing portion of the population may enter a facultative diapause while the remainder enters an obligatory diapause under normal field conditions.

INTRODUCTION

The fir engraver, *Scolytus ventralis* LeConte, infesting grand fir, *Abies grandis* (Douglas) Lindley, is normally univoltine in northern Idaho. Struble (1957) noted that the fir engraver population produced a partial second generation annually on south-facing slopes at 4000 ft. elevation in the California Sierra Nevada. In laboratory rearings about 50% of the brood emerged within 90 days of attack while the remainder emerged over the next 100 days or died (Scott and Berryman 1971), suggesting that a significant portion of the population ordinarily enters diapause. The present study reports on the effects of winter exposure on the development rate and emergence synchronization of the fir engraver.

MATERIALS AND METHODS

Six living grand firs, about 50 years of age, were felled on 8 July, 1969, during the flight period of *S. ventralis*. The trees were attacked 1 or 2 days after felling. Fifteen days after attack 24 one-foot-long bolts were cut from these trees and brought into the laboratory. Another 16 bolts were cut and brought into the laboratory on 24 November, 1969, 137 days after attack; 8 on 5 February, 1970, 220 days after attack; and 16 on 7 May, 1970, 301 days after attack.

All bolts were maintained at 25 - 30° C, 50 - 60% RH, and 16-hour photoperiod. Emergence was recorded at approximately 10-day intervals by counting and marking new emergence holes.

Mean development time from attack to peak emergence (T) was calculated by

$$T = \frac{(Xi \cdot Fi)}{N}$$

where Xi = number of days from attack to the ith emergence period, Fi = emergence during the ith period, and N = total beetles emerging. Thirty days after emergence had started to decline, the bolts were debarked and the following data collected: number of successful attacks, length of egg galleries, number and stage of the surviving brood. The bark was then dissected and the brood within recorded. Five of the bolts from the first sampling (July) were not debarked until 215 days after attack.

RESULTS AND DISCUSSION

Logs in the field were considered to be under the influence of cold temperatures during those months when the average monthly maximum temperature was below 15° C; *i.e.*, from 1 October, 1969 to 1 May, 1970 (Table 1).

TABLE 1. Average maximum and minimum daily temperatures (°C) from Potlatch, Idaho (U.S. Weather Bureau Climatological Data).

Month	Maximum	Minimum
September, 1969	21.7	4.3
October	12.7	—0.6
November	8.6	—1.8
December	2.5	—4.6
January, 1970	1.7	—5.2
February	7.7	—1.7
March	7.7	—3.3
April	9.6	—1.1
May	18.3	3.2

[1]Scientific Paper 3690, Project 1977, College of Agriculture Research Center, Washington State University. This work was supported in part by a Washington State University Grant-in-Aid (Initiative 171). The manuscript is, in part, from a thesis by the senior author in partial fulfillment of the M.S. degree, Washington State University.

[2]Associate Entomologist, Eli Lilly and Co., Greenfield, Indiana, and Associate Entomologist, Washington State University, Pullman, Washington 99163, respectively.

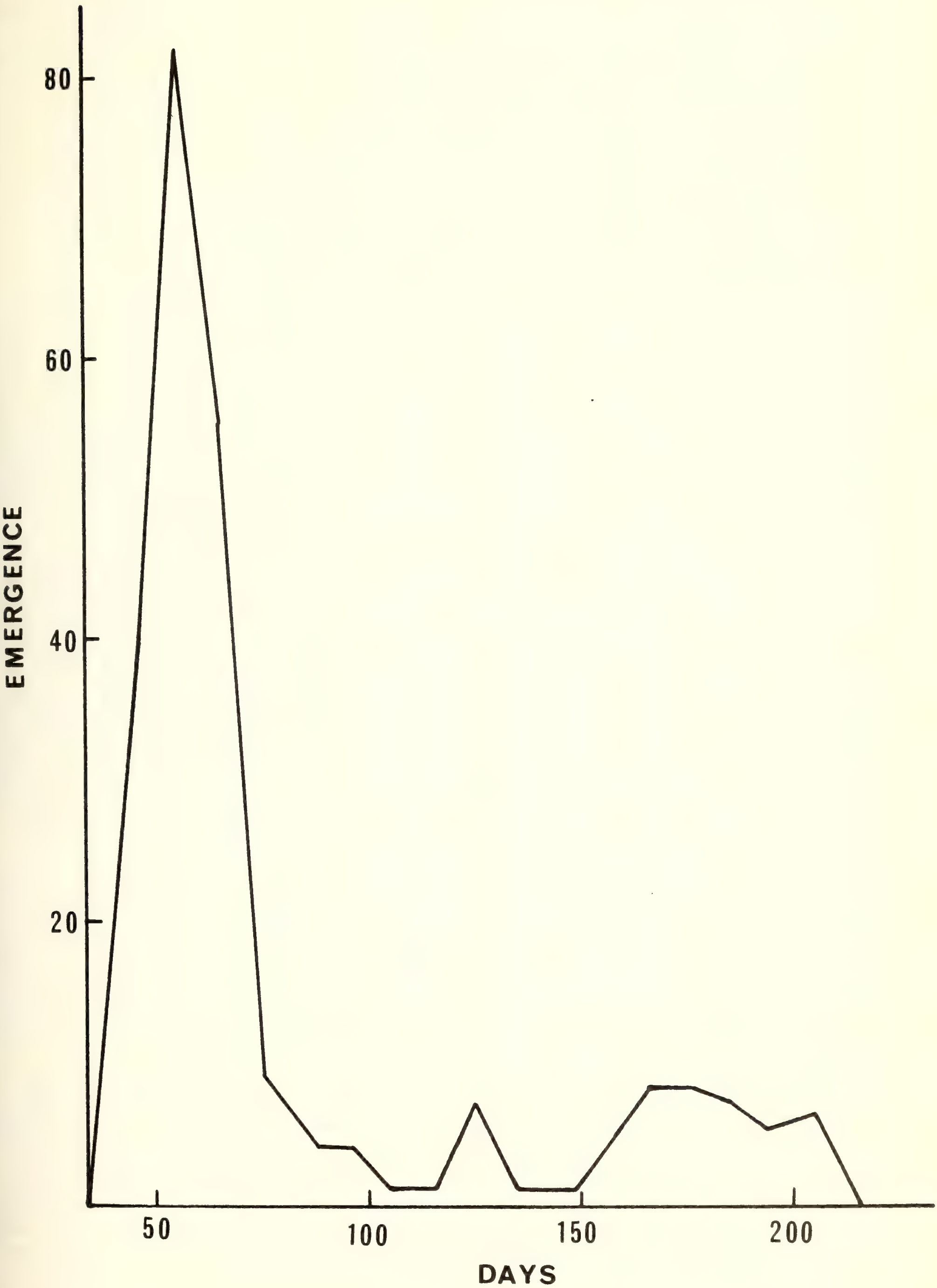

Fig. 1. Emergence pattern of **S. ventralis** reared in the laboratory without cold exposure.

TABLE II. Mean development time and emergence synchrony of **S. ventralis** in the first emergence peak after different lengths of exposure to field temperatures.

Date Sampled	No. of Bolts	Days in the field		Days in Laboratory*	Total Development Time	Per cent Emergence **
		Max.temp. > 15°C	Max.Temp. < 15°C			
7-25-69	19	15	0	43	58	68.50
11-24-69	16	82	55	58	195	90.36
2-5-70	8	82	138	34	254	98.27
5-7-70	16	82	219	30	331	100.00

*Total time in the laboratory up to the mean of the first emergence peak.
**Per cent of the population emerging within 30 days of the first emergence peak.

The first group of bolts, brought into the laboratory on 25 July, 1969, did not experience cold temperatures. At this time the fir engraver brood was in the egg and first two larval stages. Figure 1 shows the emergence pattern of *S. ventralis* from 5 of these bolts over a period of 215 days from the time of attack. Dissection of the bolts at the end of this period showed that all brood had either emerged or died. It is apparent that most emergence occurred 50-70 days after attack followed by gradual emergence with a minor peak between 150 and 210 days. The remaining 19 bolts of this group were dissected 30 days after the first emergence peak or 88 days from the time of attack. At this time 68.5% of the brood had emerged (Table 2). These results, and those of Scott and Berryman (1971), show that 50 - 70% of the brood develop rapidly at relatively constant temperatures and probably represent the proportion of the population which completes two generations a year under suitable climatic conditions in the field (Struble 1957). The development of the remaining 30 - 50% of the brood was retarded having presumably entered obligate larval diapause. This proportion probably produces a single annual generation under most field conditions.

The effects of exposure to cold temperatures on the development of *S. ventralis* was examined by collecting infested bolts from the field at three intervals during winter. The bolts brought into the laboratory in November had experienced about 55 days of temperatures below 15° C. This treatment resulted in an increased proportion of the brood emerging during the first emergence peak (Table 2); *i.e.*, diapause was broken in about 70% of the brood with an obligate larval diapause. However, it required 58 days rearing in the laboratory to reach mean emergence, or 15 days more than the brood receiving no cold treatment (Table 2). This increased development time was greater than is indicated in Table 2 because the sample taken in November had experienced 100 extra days of field temperatures in the range favorable for development. Furthermore, brood in the earlier sample was in the egg and first two larval stages while in the later sample all brood was in the mature larva or prepupal stage. These results indicate that the rapidly developing proportion of the brood had entered a facultative larvae diapause conditioned by environmental stimuli; possibly temperature or photoperiod.

The time required in the laboratory for mean emergence to occur in samples taken in February and May was reduced (Table 2). Furthermore, emergence was synchronized to a greater degree by the longer cold temperatures (Table 2). This indicated that diapause requirements for most of the larvae was satisfied by 150-200 days cold exposure.

The results of this study suggest that 50 - 70% of the larvae of *S. ventralis* have a facultative diapause initiated by undetermined environmental stimuli and that 30 - 50% have an obligatory diapause. The diapause conditions are apparently broken by exposures to cold temperatures, longer cold exposures resulting in a higher degree of emergence synchronization and a shorter period to peak emergence.

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THE DOOMSDAY BOOK

by GORDON RATTRAY TAYLOR
A Fawcett Crest Book,
World Publishing Company,
New York & Toronto.
Pp. 320. $1.25

Until such time as Paul and Anne Ehrlich's well researched hard-cover "Population, Resources, Environment" also appears in paperback, "The Doomsday Book" remains, in my view, the most readable, and probably the most important of the spate of popular, doom-and-gloom, ecology books; it has been in paperback only since September, 1971. It may be that the author's 1968 "The Biological Time Bomb" will prove more prophetic and in the long run more important, but it lacks the immediacy and urgency of the present work. This time the author avoids speculation and extrapolation wherever possible; instead he presents a fairly low-keyed digest of recently published work, lightly footnoted, annotated, referenced, and indexed. The data are largely from reputable original sources and reviews, notably and frequently from Nature, Science, New Scientist, Science News, and Scientific American.

Isaac Asimov refers to The Doomsday Book as "cool and unimpassioned", which well describes the writing. The tone should be acceptable both to the converted and to any layman who is not very clear on the ecology furore but is not about to be stampeded by rhetoric or emotion. A few degrees of emotional heat do break through occasionally, for example in the section on radioactivity (chap. 8).

In any book as wide ranging as this, nit picking is easy. On p.85 we read that "the Tasmanian 'wolf' was . . . believed to be a predator — actually it is not a carnivore but a marsupial like a kangaroo." It is a marsupial alright, but a predator too — and probably extinct by now. Some examples from entomology are greatly oversimplified, e.g. the case of the codling moth (p.84). Aldrin and dieldrin (p.128) are the terrible organophosphorus twins. Plague is spread by lice (p.77). But a dividend from the all-embracing approach is that DDT loses some of its preeminence and falls into its proper place as merely the most widespread and one of the most damaging pollutants amongst such other horrors as cadmium, mercury, lead, polycholoro-biphenyls, asbestos, carbon monoxide, nitrites, nitrogen oxides, and radioactive wastes.

In "Ice Age or Heat Death" (chap.3) the conflicting arguments for both fates will probably confuse the reader. But he can hardly fail to realize, first, that astonishingly small inputs to the atmosphere will surely have an effects of some kind on the earth, ". . . climate is nothing like as stable as we tend to think," (p. 79); and second, that the whole earth is so closely tied to and affected by its atmosphere and climate that unpleasant changes may appear at several removes from the triggering mechanism," . . . the web of cause and effect is too complicated for our present levels of scientific understanding, . . ." (p.73).

The author is at his best on the food and population crises and in marshalling his arguments against nuclear power. The views of Gofman and Tamplin are presented at some length in a 30-page section on radioactivity (chap.8).

It takes two full pages to acknowledge those who helped the author, including 18 very distinguished discussants (e.g. La Mont Cole, Fraser Darling, Kingsley Davis, Paul Ehrlich, Glenn Seaborg, Stewart Udall), and 56 others with impeccable affiliations, who gave help and information, including Barry Commoner, J. W. Gofman, Chas. F. Wurster and many Europeans.

On the cover of the paperback the publisher has put the cheering message: "Mankind can survive." The author seems to be less than certain.

H. R. MacCarthy

THE ESTABLISHMENT OF THREE EXOTIC APHID PARASITES (HYMENOPTERA: APHIDIIDAE) IN BRITISH COLUMBIA

M. MACKAUER AND A. CAMPBELL
Department of Biological Sciences,
Simon Fraser University, Burnaby 2, British Columbia

ABSTRACT

Praon exsoletum palitans, Aphidius ervi ervi and the **Orange** phenotype of **Aphidius smithi** are recorded from British Columbia. Release data, present distribution, host records, and diagnostic criteria are included.

During the past 15 years an extensive campaign has been carried out to introduce and establish exotic hymenopterous parasites of various pest aphids in the continental United States and, to a lesser degree, in Canada. A number of the aphidiid parasites that were released in the mid-western and western United States subsequently spread and invaded adjoining parts of Canada. This paper reports on the recovery of three aphidiid species in southern British Columbia. The specimens were obtained in the course of a faunistic survey of aphids and aphid parasites, in particular of species associated with alfalfa fields.

General records on the taxonomy, distribution, and known host range of the three aphid parasites discussed below were given by Mackauer and Stary (1967).

Praon exsoletum palitans **Muesebeck**

Praon palitans Muesebeck, 1956. Bull. Brooklyn ent. Soc. 51: 27-28, figs. 2, 2 a, ♀ ♂ (Orig. descr.).

Praon exoletum palitans: Mackauer, 1959. Beitr. Ent. 9: 828-833, figs. 8, 17, ♀ ♂ Geogr. subsp. of *Praon exsoletum* (Nees).

Praon exsoletum palitans: Mackauer, 1968. Hym. Cat., n. edit., 3: 16-17 (Tax., emend.).

The species was introduced from the Mediterranean area and was released against the spotted alfalfa aphid, *Therioaphis trifolii* (Monell), in California during 1955 and 1956. The parasite became established in southern California in 1956 and subsequently spread over large areas of that state (Van den Bosch *et al.* 1959). It was reported by Muesebeck (1967) from Arizona, California, Colorado, Kansas, Nebraska, Nevada, New Mexico, and Utah, and by Angalet (1970) from Delaware, Maryland, and New Jersey.

Two male specimens of *Praon exsoletum palitans* were collected near the Canada Department of Agriculture Research Station, at Kamloops, on 2 June 1971. The parasites were bred from one alate female and one apterous second or third instar nymph of the sweetclover aphid, *Therioaphis riehmi* (Börner), on white sweetclover, *Melilotus alba*. This record is the first record of the species from Canada.

Praon exsoletum palitans resembles the Nearctic species *P. negundinis* Smith in coloration, the pilosity of the mesoscutum, and in the average number of antennal segments. It can be distinguished chiefly by the recurrent vein of the forewings which is either incomplete or lacking and, in the female, by the broad ovipositor sheaths (Mackauer 1959, Smith 1944). The host range of *P. exsoletum* is restricted to *Therioaphis* species which feed on herbaceous legumes, whereas *P. negundinis* appears to be a specific parasite of *Periphyllus* species feeding on maples (Mackauer and Stary 1967).

Aphidius ervi ervi Haliday

Aphidius (Aphidius) ervi Haliday, 1834. Ent. Mag. 2: 100, ♀ ♂ (Orig. descr.).

Aphidius medicaginis Marshall in Andre, 1898. Spec. Hym. Eur. Alg., 5 bis: 249-250, ♀ ♂ (Orig. descr.).

Aphidius fumipennis Györfi, 1958. Acta Zool. hung. 4: 133, ♂ (Orig. descr.).

Aphidius ervi ervi: Mackauer, 1962. Beitr. Ent. 12: 641-642 (Geogr. subspp.).

Aphidius ervi ervi: Mackauer, 1968. Cat. Hym., n. edit., 3: 46-47 (Tax.).

Colonies of *Aphidius ervi ervi* which originated from various European localities were released against the pea aphid, *Acyrthosiphon pisum* (Harris), in the western United States between 1959 and 1965 (Table

TABLE I. Open releases of **Aphidius ervi** ervi Haliday in western North America.

Year	Release area	Origin	Authority
1959	California	France	J.R. Coulson 1)
1961	Arizona, Washington	France	J.R. Coulson 2)
1961	Oregon, Washington	France, Germany	B.J. Landis 3)
1962	Idaho	Poland	J.R. Coulson
1963	Idaho, Washington	eastern U.S.A.	J.R. Coulson 4)
1965	California	Lebanon	D.A. Chant, R.L. Doutt 3)

1) Reported originally as **Aphidius medicaginis** and field-released according to Univ. of California records.
2) Reported originally as **Aphidius** sp. (ex pea aphid) and **Aphidius urticae.**
3) Reported in Mackauer and Finlayson (1967).
4. Reported originally as **Aphidius** sp. and **Aphidius ervi** collected in New Jersey and Pennsylvania. This record requires verification as the released material in fact may have belonged to **A. ervi pulcher** and not to **ervi ervi.**

1). The overall similarity between this species and the indigenous *A. ervi pulcher* and the fact that both species interbreed, it was suggested by Mackauer (1969, 1971), may be the reasons why proof of the establishment of *ervi ervi* in any of the United States release areas has been lacking so far.

The first specimens which were suspected to belong to *A. ervi* were collected near Kamloops during the summer of 1970. During 1971 additional material was obtained from the following localities: C.D.A. Research Station Kamloops (June-October), 5 mi S of Round Lake (8 August), Winfield (30 July), and Chilliwack (6 August, 15 September). All parasites were reared from pea aphids on alfalfa. The percent contribution of *ervi ervi* to the total number of primary parasites attacking the pea aphid in each locality ranged from 0.1 to 1.3 %, except for Chilliwack where 88.2 % out of a total of 304 parasites examined belonged to *ervi ervi.* In addition, some representatives of the species were bred from parasitized pea aphids that had been collected near Burlington, Washington, on 20 June 1970. Our records are the first evidence of the successful colonization and establishment of *A. ervi ervi* in Canada and the United States.

Of the three *Aphidius* parasites of the pea aphid which are known to occur in western Canada the yellowish-orange coloured *A. smithi* may be separated from the predominantly fuscous-to-black coloured *A. ervi ervi* and *ervi pulcher* on the basis of colour and the relative length of the third antennal segment (Mackauer and Finlayson 1967). Differences in the female genitalia (Figs. 4, 6, 8) are helpful but do not permit an accurate identification. The diagnostic criteria of the petiole that were described by Eady (1969) were found to be useful for the determination of between 90 and 95% of all specimens examined. Typically the anterolateral area of the petiole shows a rugose sculpture in *A. ervi ervi* (Fig. 3), while in *ervi pulcher* and *smithi* the same area is striated (Figs. 5, 7). The centrodorsal area of the petiole is coarsely sculptured in *ervi pulcher* (Fig. 1) but comparatively smooth in *smithi* (Fig. 2). These characteristics vary with the size of the specimen in that smaller specimens tend to show a less distinct sculpture. If live material is available for breeding all identifications should be verified by determining the colour and range of coloration under known temperature and humidity conditions in the laboratory.

***Aphidius smithi* Sharma and Subba Rao**

Aphidius (Aphidius) smithi Sharma and Subba Rao, (1958) 1959. Indian J. Ent. 20: 183, 186-187, Pl. II, 1-5, Pl. III, 1-3, ♀ ♂ (Orig. descr.).

Aphidius smithi: Mackauer, 1968. Cat. Hym., n. edit., 3: 56 (Tax.).

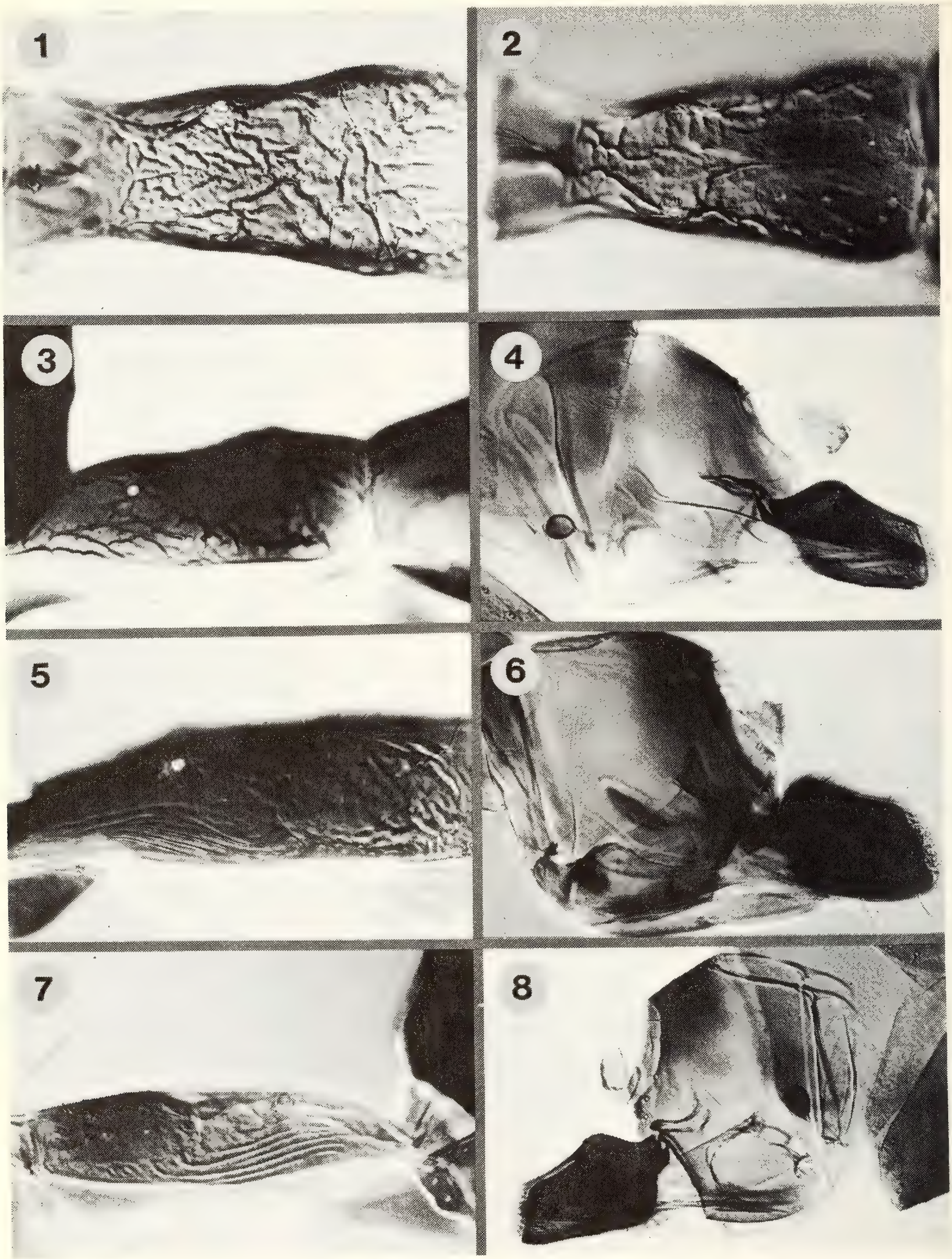

Fig. 1. **Aphidius ervi pulcher,** ♀, centrodorsal area of petiole.

Fig. 2. **Aphidius smithi,** ♀, centrodorsal area of petiole.

Figs. 3, 4. **Aphidius ervi ervi,** ♀. 3, anterolateral area of petiole; 4, genitalia.

Figs. 5, 6. **Aphidius ervi pulcher,** ♀. 5. anterolateral area of petiole; 6, genitalia.

Figs. 7, 8. **Aphidius smithi,** ♀. 7, anterolateral area of petiole; 8, genitalia.

(See text for details. Nomarski differential-interference contrast photographs of unstained specimens mounted in Hoyer's medium.)

The parasite was imported from India and released against the pea aphid, *Acyrthosiphon pisum*, in large areas of the United States and eastern Canada between 1958 and 1967 (Mackauer 1971, Mackauer and Bisdee 1965). It became established almost immediately upon its release in California (Hagen and Schlinger 1960) but was not recovered in the eastern United States and Canada until the fall of 1964 (Angalet and Coles 1966, Mackauer and Bisdee 1965). The present distribution of *A. smithi* includes California, Colorado, Idaho, Kansas, and Washington in the Western United States (Musebeck 1967), and Alberta (new record) and British Columbia in western Canada.

Further examinations showed that western populations of *A. smithi* are monomorphic, or largely so, with regard to a gene *Orange (O)* which affects the abdominal pigmentation, while eastern populations are generally dimorphic for the character. It was suggested by Mackauer (1968, 1971) that the *Orange* gene arose as a new mutation among released specimens in the eastern United States and, in fact, may have been involved in the establishment of the species under initially adverse climatic conditions.

In July 1965 *A. smithi* was collected near Christina Lake indicating that the parasite had successfully invaded British Columbia from release sites in the western United States (Mackauer and Finlayson 1967). These first specimens were all wild-type. Since 1965 the species has spread through most of southern British Columbia and in 1971 was the most common of the primary parasites of the pea aphid in the interior of the Province. The first representatives of the *Orange* phenotype were collected W of Bridesville and near Kamloops in the summer of 1971, where they contributed 0.6 and 0.2 %, respectively to the total number of pea aphid parasites.

Acknowledgments

We thank Drs. J. R. Coulson and B. Puttler, of the United States Department of Agriculture, for making available unpublished information on the releases of hymenopterous parasites of the pea aphid in the United States. Professor T. Finlayson, of this Department, verified our identification of **Aphidius ervi ervi** by examining the cast skins of the final instar larvae. The work was supported in part by a National Research Council of Canada Operating Grant to the senior author.

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THE LEAFHOPPER GENUS *EMPOASCA* SUBGENUS *KYBOS* IN THE SOUTHERN INTERIOR OF BRITISH COLUMBIA

K. G. A. Hamilton [1]

Entomology Research Institute
Canada Department of Agriculture
Ottawa, Ontario

ABSTRACT

The 22 species reported here represent 7 new species, 10 new Canadian records, and 5 previous records. **E. caesarsi, E. columbiana, E. coronata, E. dissimilaris, E. empusa, E. rossi,** and **E. tigris** n. spp. are described and illustrated. New Canadian records are **E. alaskana** Ross, **E. andresia** Ross, **E. betulicola** Wagner, **E. copula** DeLong, **E. exiguae** Ross, **E. fontana** Ross, **E. gelbata** DeLong & Davison, **E. portola** Ross, **E. rubrata** DeLong & Davidson, and **E. trifasciata** Gillette. Brief descriptions and a key are provided.

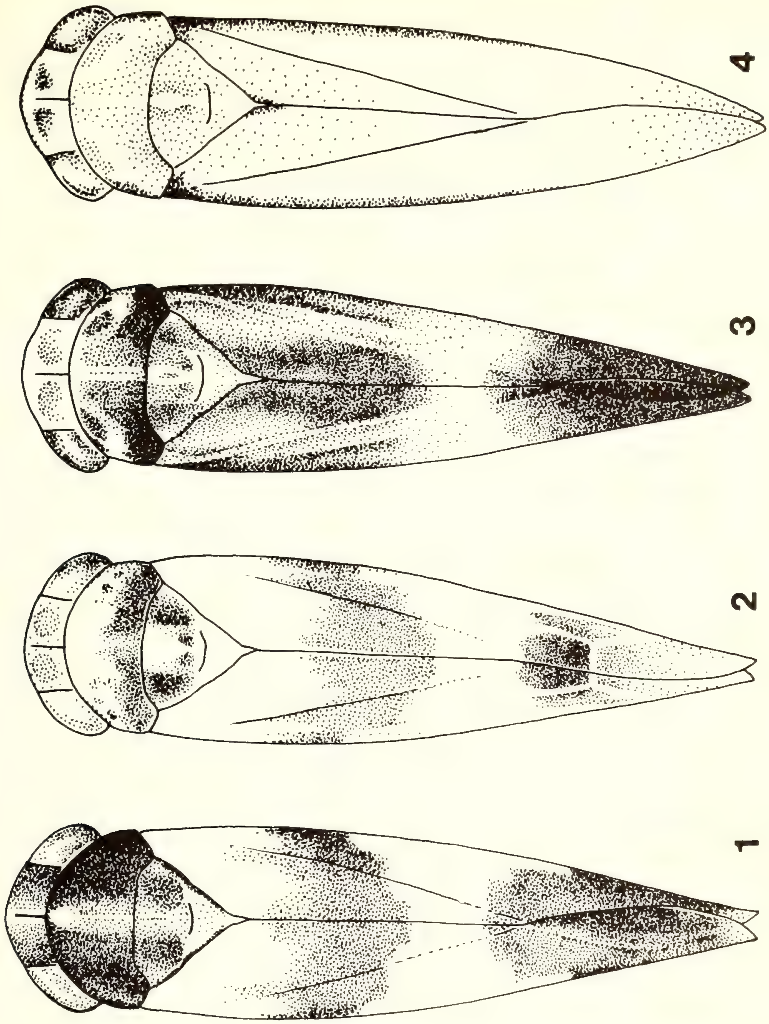
One of the most poorly studied genera of Canadian leafhoppers is *Empoasca* Walsh. This is a very large genus of small, green to orange insects that feed on a wide variety of forages, shrubs, and trees; many species are common, and quite a few are considered economically important, both for the damage they cause in feeding and for the transmission of "viral" diseases of crops.

The genus is divided into three subgenera: *Empoasca* sensu stricto, *Kyboasca* Zachvatkin and *Kybos* Fieber. The first encompasses the majority of species, which feed mainly on forages and shrubs. There are many species complexes in this group, requiring much biological data to determine the specific limits. The available information is too incomplete at present to permit adequate treatment of this subgenus. *Kyboasca* is a small subgenus, characterized by the numerous tergal apodemes in the male abdomen. The species feed on a variety of trees, other than willow and poplar. All but two species collected in British Columbia have been previously recorded from Canada by Beirne (1956). The third subgenus is a moderately large group of species feeding almost exclusively on willows (*Salix* spp.) and poplars (*Populus* spp.). *Kybos* is very well represented in British Columbia; I have taken 22 species in the interior, and others probably await discovery. Only 4 of these were previously recorded by Beirne, and another by Ross (1963). Most of the new Canadian records are of species found in adjacent areas in the United States.

The subgenus *Kybos* is characterized by male genitalia in which the anal hooks are strongly curved, and the minutely serrate style apices are curved and bear very long, fine setae. The subgenus may be more readily recognized by the chaetotaxy of the plates. The macrosetae are longer than the width of the plates, and either scattered over the ventral surface or arranged in many rows, instead of being short and biserrate, as in the other subgenera.

Characters used in identifying the species are the shape of the anal hooks and brachones (ventral pygofer processes), and the chaetotaxy of the base of the sub-genital plates. The apodemes of the second sternite and the third and fourth tergites (2S, 3T, 4T) of the male abdomen are also useful, although parasitized specimens are often encountered in which these are greatly reduced. Some species have distinctive colour patterns, and may thus be

[1] Present address: Department of Entomology, University of Georgia, Athens, Ga. 30601.



Figures

Figs. 1-4. Habitus of **Empoasca (Kybos)** spp. 1, **E. tigris** n. sp., male; 2, same, female; 3, **E. dissimilaris** n. sp., male; 4, same, female.

readily identified without dissection. Females are usually impossible to identify without associated males.

All types are deposited in the Canadian National Collection, Ottawa. (C.N.C.).

Key to males of species of *Empoasca* (Kybos) Fieber.

1. Dark, pronotum and scutellum wholly or partly deep reddish of fuscous; tegmina usually strongly coloured or marked with fuscous (Fig. 3) 14

—. Pale, pronotum, scutellum and tegmina concolourous green, yellow or golden-orange; tegmina marked at most with weak fuscous dusting along veins and apical third (Fig. 4) 2

2. Dorsal margin of base of plates with long, stout, parallel-sided setae like those of ventral surface 10

—. Dorsal margin of base of plates with fine, tapered setae 3

3. Apodemes 4T larger than 3T or 2S (Fig. 9) .... **rossi** n. sp.

—. Apodemes 4T linear or absent, smaller than 3T and 2S 4

4. Brachone strongly clubbed (Beirne, 1956, Fig. 1028); head with red band between eyes near anterior margin **carsona** DeL. & Dav.

—. Brachone not strongly clubbed; head unmarked with red 5
5. Apodemes 2S more than 2 segments long (Fig. 11) 9
—. Apodemes 2S less than 2 segments long (Fig. 7) 6
6. Apodemes 3T lobed, more heavily sclerotized than apodemes 2S 8
—. Apodemes 3T linear, similarly sclerotized to apodemes 2S 7
7. Apodemes 2S wider than long; apodemes 3T sinuate . . . . **incida** DeL.
—. Apodemes 2S longer than wide; apodemes 3T straight . . . . **fontana** Ross
8. Apodemes 3T exceeding tips of apodemes 2S . . . . **caesarsi** n. sp.
—. Apodemes 2S exceeding tips of apodemes 3T . . . . **columbiana** n. sp.
9. Apodemes 2S fully 4 segments long; apodemes 3T regularly lobate . . . . . **patula** DeL.
—. Apodemes 2S only 3 segments long; apodemes 3T arched outwards . . . **exiguae** Ross.
10. Apodemes 2S at least 3 segments long; apodemes 3T linear . . . . **portola** Ross
—. Apodemes 2S much less than 3 segments long; apodemes 3T lobate 11
11. Apodemes 3T over half as long as 2S; base of plates with only dorsal comb of setae . . . . **andresia** Ross
—. Apodemes 3T less than half as long as 2S; base of plates with several peg-like setae on anterior margin as well as with dorsal comb of setae 12
12. Apodemes 2S over 3 segments long (Fig. 1) . . . . **empusa** n. sp.
—. Apodemes 2S not over 2 segments long (Fig. 10) 13
13. Deep green; tip of brachone strongly flattened (Fig. 18b) . . . . . . **coronata** n. sp.
—. Yellowish-green; tip of brachone tapered (Fig. 20b) . . . . **gelbata** DeL. & Dav.
14. Transversely banded (Fig. 1) 21
—. Longitudinally striped, or with indefinite markings (Fig. 3) 15
15. Brown markings a patch on pronotum and tegminal tips, and along commissure and claval suture; anal hook very stout . . . . **betulicola** Wagner
—. Brown markings otherwise, more extensive on dorsum of thorax; anal hook slender . . 16
16. Apodemes 3T shorter than half length of 2S 19
—. Apodemes 3T over half as long as apodemes 2S 17
17. Apodemes 2S longer than 3T, turned outwards at tips . . . . **alaskana** Ross
—. Apodemes 2S not longer than 3T, evenly curved at tips 18
18. Apodemes 3T and 2S subequal, less than 2 segments long . . . . **alberta** Ross
—. Apodemes 3T longer than 2S, more than 2 segments long . . . . **dissimilaris** n. sp.
19. Apodemes 3T lobate, 1/3 length of 2S; base of plates with only dorsal comb of setae . . . . **lucidae** Ross
—. Apodemes 3T linear and minute, or absent; base of plates with peg-like setae on anterior margin as well as dorsal comb of setae 20
20. Markings brownish; apodemes 2S more than 2 segments long . . . . **copula** DeL.
—. Markings reddish; apodemes 2S less than 2 segments long . . . . **rubrata** DeL. & Dav.
21. Brachone widened at end; tegmina greenish to bright green . . . . **trifasciata** Gillette
—. Brachone tapered to tip; tegmina pale yellow . . . . **tigris** n. sp.

EMPOASCA *(Kybos)* ALBERTA Ross

Empoasca (Kybos) alberta Ross, 1963: 216.

Blackish-brown with basal half of the tegmina brown, fading to hyaline tips; distinctive subequal 2S and 3T apodemes. Collected from: Okanagan Mission, Bear Creek (Westside Road, L. Okanagan), Creston, and Baldy Mountain, at 6500' (north of Bridesville): 4 specimens.

Host: recorded by Ross as *Salix* sp. Probably double-brooded; June to early July, and August.

EMPOASCA *(Kybos)* ALASKANA Ross

Empoasca (Kybos) alaskana Ross, 1963: 219 (new Canadian record).

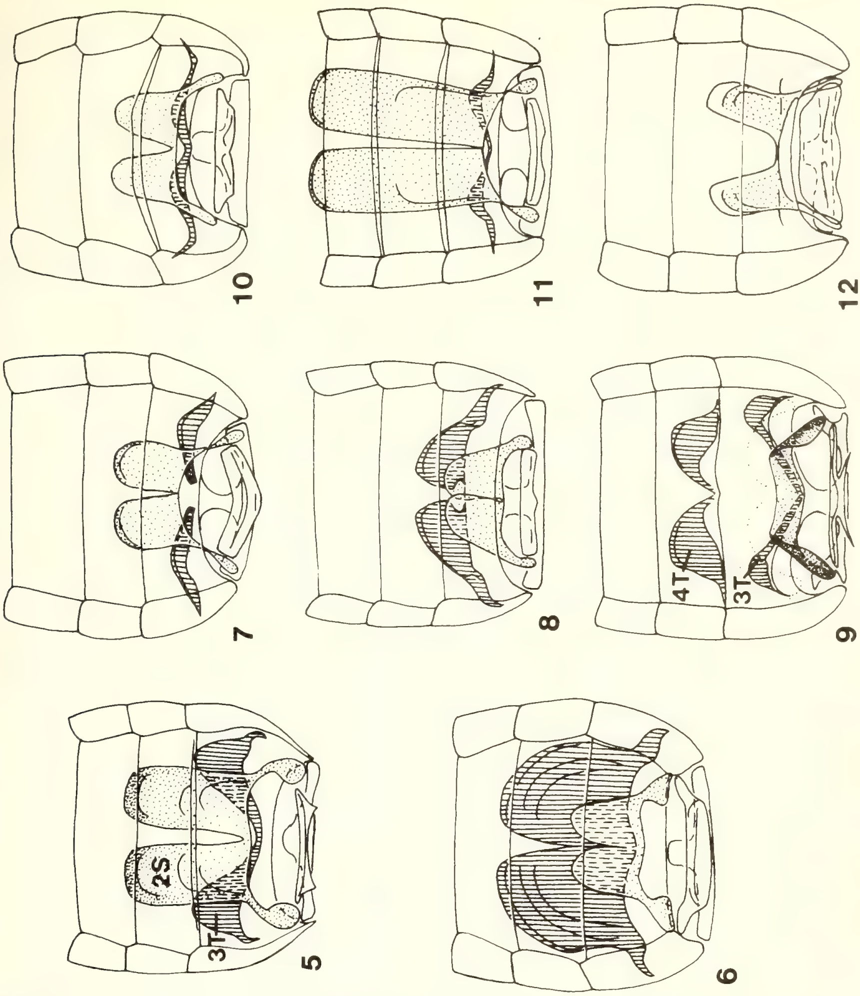
Sordid ochreous, with commissure deep brown; distinctive large 3T apodemes and divergent tips of 2S apodemes. Collected from: Naramata: 1 specimen.

Host: unknown. Collected in late July.

EMPOASCA *(Kybos)* ANDRESIA Ross

Empoasca (Kybos) andresia Ross, 1963: 218 (new Canadian record).

Yellow-green, with smoky wing tips and often also infuscated veins; distinctive short, lobate apodemes. Collected from: Armstrong, Creston, Naramata, Okanagan Mission, Otter Lake (south of Armstrong), Penticton, Salmon Arm, Summerland, and the following locations on the Westside Road of Lake Okanagan:



Figs. 5-12. Base of abdomen of **Empoasca (Kybos)** spp., showing second sternal (2S) apodemes stippled, third and fourth tergal (3T, 4T) apodemes hatched. 5, **E. tigris** n. sp.; 6, **E. dissimilaris** n. sp.; 7, **E. columbiana** n. sp.; 8, **E. caesarsi** n. sp.; 9, **E. rossi** n. sp.; 10, **E. coronata** n. sp.; 11, **E. empusa** n. sp.; 12, **E. rubrata** DeL. & Dav.

Bear Creek, Caesars, Ewings Landing, Nahun, and Wilson Landing: 205 specimens.

Host: recorded by Ross as various species of *Salix*. Single-brooded; mid-June through August, commonest in late July.

In view of the numerous records of this species from traps on sweet cherry, choke cherry, and bitter cherry *(Prunus emarginata* Dougl.) it seems likely that adults, at least, also feed on various species of *Prunus*.

EMPOASCA *(Kybos)* BETULICOLA

Empoasca betulicola Wagner, 1955; 178 (new Canadian record).

Yellow with tegmina and legs bright green, heavily marked with fuscous on center of pronotum, along commissure and claval sutures, and on apical third of tegmina. Collected at Kelowna: 1 specimen.

Host: *Betula alba* L. Specimen taken on *Populus sargentii* Dode.

EMPOASCA *(Kybos)* CAESARSI n. sp.

(Figs. 8, 16)

Male. Length, 4.7 mm. Colour yellow-green, with slight orange cast on head and pronotum; tegmina green, claval suture white. General structure typical for subgenus. Apodemes 2S short, not extending into fourth segment, broadly lobate, turned inwards and

slightly overlapping; apodemes 3T short, very broad, strongly angled mesad, projecting only 1/3 the length of fourth tergite, connected by very slender ridge. Eighth sternite weakly and bluntly produced. Anal hook tapered, evenly curved to sinuate tip. Brachone parallel-sided to attenuate, slender tip, curved most strongly at base. Base of plates with one row of erect marginal tapered setae and a second of recumbent setae of similar size.

Female. Length, 4.7 mm. Colour yellow-green, marked with white as follows: face with arrow-shaped mark pointing to marginal coronal dashes, dorsum with median line and paired longitudinal dashes on crown also; tegmina smoky green, with white claval suture. Seventh sternite very strongly produced to rounded tip, with prominent lateral angles.

Types. Holotype, ♂, Caesars, Westside Road, Okanagan Valley, B.C., 16-28 July 1971, sticky board trap on *Prunus emarginata*. Allotype, ♀, same data as holotype. Paratype: 1 ♀, same data as holotype. C.N.C. type number 12570.

Remarks. The very short and lobate apodemes are comparable only to those of *albolinea* Gillette; the shape of the 2S apodemes and the colour pattern of the female also indicate this relationship. *E. caesarsi* may be distinguished from this species by the shape of the 3T apodemes, the curvature of the brachone, and the prominent lateral angles of the female seventh sternite.

The fact that these specimens were taken on bitter cherry should not be interpreted as indicating that this is the host of *caesarsi.*

EMPOASCA *(Kybos)* CARSONA DeLong & Davidson

Empoasca carsona DeLong & Davidson, 1936: 229.

Empoasca aureoviridis; Beirne, 1956: 60.

Unmarked green to pale ochreous, with transverse red line between eyes (individuals may be patterned heavily with red); distinctive clubbed brachone. Collected from: Creston, Kelowna, Okanagan Mission, Penticton, Summerland, and Caesars (Westside Road, Lake Okanagan): 75 specimens.

Host: recorded by Ross as *Populus balsamifera* L. Local host: *P. trichocarpa* Torr. & Gray; a single specimen taken on *Populus sargentii*. Possibly double-brooded; late June to early July, and August.

EMPOASCA *(Kybos)* COLUMBIANA n. sp. (Figs. 7, 15)

Male. Length, 4.1 - 4.3 mm. Colour yellow-green, tegmina white, basally and apically lightly fuscous; abdominal tergites spotted with fuscous. General structure typical for subgenus. Apodemes 2S short, extending halfway into fourth segment, apically rounded, apodemes 3T short, scarcely lobate, separated at meson. Eighth sternite weakly produced. Anal hook long and slender, evenly curved cephalad. Brachone paralled-margined, apically slender, tapered to slightly sinuate tip. Base of plates with 3-5 long, slender, tapered setae.

Female. Unknown.

Types. Holotype, ♂, Otter Lake, south of Armstrong, British Colunbia, 15-29 July 1971, sticky board trap on *Prunus emarginata*. Paratypes, 1 ♂, same data, Armstrong, B.C., 3 ♂♂, same data, 30 July - 12 August 1971. C.N.C. type number 12571.

Remarks. The small, separated 3T apodemes ally this species to *occidua* Ross, from which it can be readily distinguished by the shorter 2S apodemes and the long, slender brachone tip. The length of the plate setae show its relationship to the *occidua* complex rather than to members of the *carsona* complex, which it otherwise resembles.

The fact that the types were taken on bitter cherry should not be interpreted as indicating that this is the host for the species.

EMPOASCA *(Kybos)* COPULA DeLong

Empoasca copula DeLong, 1931: 27 (new Canadian record).

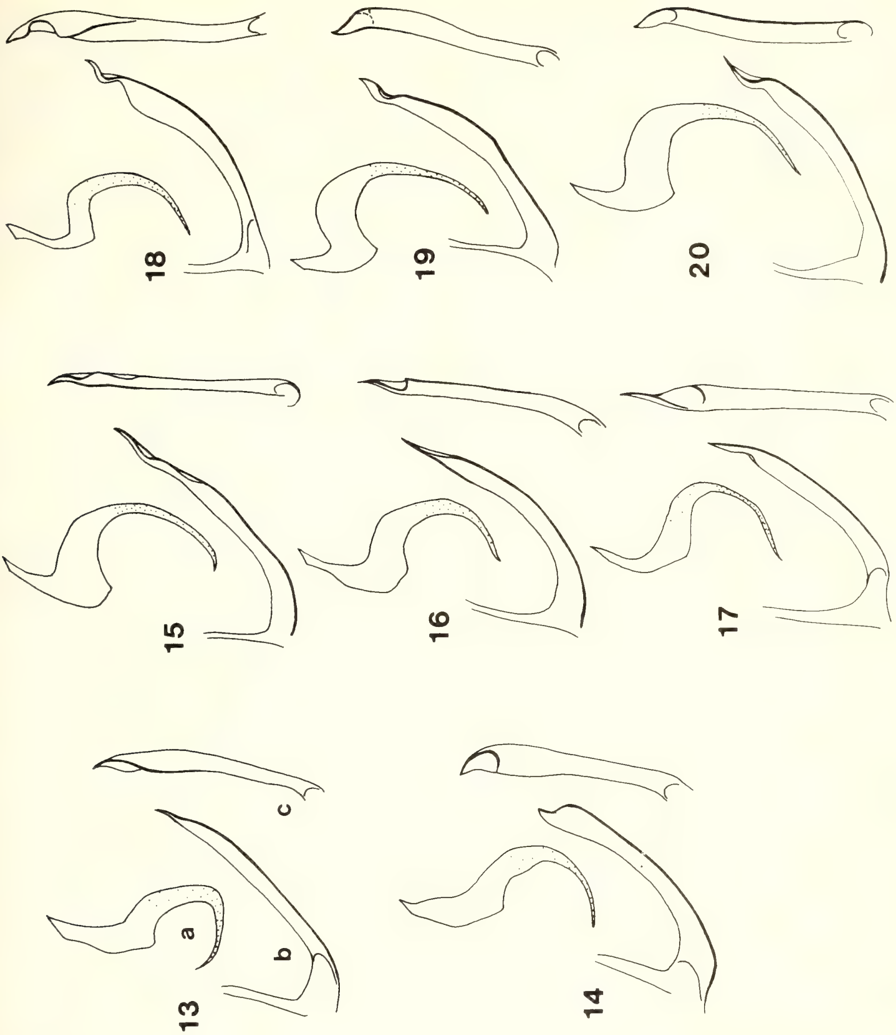
Green, with distinctive but indecisive markings: head orange, pronotum and wing apices deep brown, abdomen bearing a red spot at center, showing through clouded patch on wings as a brownish bar, giving specimens a banded appearance. Collected from: Ewings Landing, Okanagan Mission, and Summerland: 11 specimens.

Remarks. The species reported by Beirne (1956) as *copula* is the unmarked, orange and green *E. alexanderae* Ross.

Host: *Populus tremuloides* Michx. Single-brooded: mid-June through July.

EMPOASCA *(Kybos)* CORONATA n. sp. (Figs. 10, 18)

Male. Length, 3.9 - 4.3 mm. Colour deep green, unmarked; head turning golden-orange on drying. General structure typical for subgenus. Apodemes 2S short, extending halfway into fourth segment, evenly lobate,



Figs. 13-20. Genitalic hooks. a, anal hook, lateral aspect; b, brachone, lateral aspect, c, same, caudal aspect. 13, **E. tigris** n. sp.; 14, **E. dissimilaris** n. sp.; 15, **E. columbiana** n. sp.; 16, **E. caesarsi** n. sp.; 17, **E. rossi** n. sp.; 18, **E. coronata** n. sp.; 19 **E. empusa** n. sp.; 20, **E. rubrata** DeL. & Dav.

narrowly separated; apodemes 3T scarcely lobate, fused mesally. Eighth sternite strongly and convexly produced mesally, with tiny lateral angles. Anal hook tapered, evenly curved cephalad. Brachone widening to abruptly flattened and twisted apex, turned slightly laterad at tip. Base of plates with four long, parallel-margined setae dorsally and three peg-like setae on anterior margin.

Female. Length, 4.1 - 4.5 mm. Colour deep green, unmarked. Seventh sternite strongly tapered, strongly produced to bluntly angled apex; lateral margins with weakly rounded angles; folded on meson.

Tpyes. Holotype, ♂, Powell Beach, Summerland, B.C., 17 June 1971, K. G. A. Hamilton, on *Populus tremuloides*. Allotype, ♀, Summerland, 23 June 1971, K. G. A. Hamilton, on *Populus tremuloides*. Paratypes; 2 ♂♂, 1 nymph, same data as holotype; 5 ♂♂, 5 ♀♀, same data as allotype; 7 ♂♂, same data, 5 July 1971. C.N.C. type number 12572.

Remarks. The apodemes of the abdomen indicate that this species is a close relative of *E. alexanderae* Ross, from which it may be

distinguished by the shorter and nearly separate 3T apodemes. The colour and flattened brachone tip distinguish this species readily from both *alexanderae* and *gelbata*.

Host. *Populus tremuloides*. Single-brooded: mid June to early July.

EMPOASCA *(Kybos)* DISSIMILARIS n. sp.

(Figs. 3, 4, 6, 14)

Male. Length, 4.0 - 4.5 mm. Colour golden, deepening anteriorly, orange head, paling to lemon-yellow on abdomen and whitish hyaline on posterior 2/3 of tegmina, sternites infuscated, marked with blackish-fuscous as follows: paired coronal spots on head, all of pronotum except anterior margin and median line, anterior 2/3 of scutellum, basal half and apical third of tegmina, paler to whitish along claval suture. General structure typical for subgenus. Apodemes 2S small, lobate, appressed, extending into fourth segment, overshadowed by apodemes 3T which are very large and broad, hood-shaped, appressed, extending into fifth segment. Eighth sternite weakly and roundedly produced to tiny apical notch, wrinkled on posterior margin. Anal hook short, tapered, evenly curved anteroventrad. Brachone apically clubbed, tip acute, directed laterad. Base of plates with many long, fine, tapered setae.

Female. Length, 4.3 - 4.7 mm. Colour bright green, yellow on face, dorsum and tegmina golden, slightly fuscous apically; marked with deep green laterally and paired coronal spots. Seventh sternite very strongly produced between prominent lateral angles to truncate tip.

Types. Holotype, ♂, Summerland, B.C., 11 June 1971, K. G. A. Hamilton, on *Populus trichocarpa*. Allotype, ♀, same data as holotype. Paratypes: 16 nymphs, 6♂♂, 3♀♀, same data as holotype; 2 nymphs, 2♂♂, 2♀♀, same data, 16 June 1971; 5♂♂, 4♀♀, same data, 17 June 1971; 1♂, 1♀, Summerland, 23 June 1971, K. G. A. Hamilton, on *Populus tremuloides;* 1♂, Summerland, 15 June 1971, K. G. A. Hamilton, on weeds; ♂, Summerland, mid-June 1970, on sticky board trap on cherry; 1♂, same data, 21-27 July 1970; 1♂, Okanagan Mission, B.C., June 1970, sticky board trap on cherry; 1♂, Ewings Landing, June 1971, sticky board trap on *Prunus emarginata*. C.N.C. type number 12573.

Remarks. The extreme sexual dimorphism in colour is unusual for this genus. The apodemes and plate setae are intermediate in length between those of *amicis* Ross and *annella* Hartzell, both of which this species resembles in genitalic characters. This species probably links the other two, providing evidence that the lineage to *annella* and *alberta* probably belongs to the *trifasciata* group rather than to the *butleri* group of Ross. The female seventh sternite is unique and highly distinctive.

Host. *Populus trichocarpa*. Single-brooded; mid June-July.

EMPOASCA *(Kybos)* EMPUSA n. sp.

(Figs. 11, 19)

Male. Length, 3.5 mm. Colour green, dorsum with bronze sheen. General structure typical for subgenus. Apodemes 2S very long and narrow, extending into sixth segment; apodemes 3T tiny, band-like, scarcely lobate. Eight sternite roundedly produced to mesal notch, between small lateral angles. Anal hook very long and slender, nearly straight, curved cephalad at tip. Brachone widened on apical half, apex narrowed and sinuate, directed laterad. Base of plates with three peg-like setae directed cephalad and four long, stout, parallel-margined setae on dorsal edge.

Female. Unknown.

Types. Holotype, ♂, Armstrong, B.C., 15-29 July 1971, sticky board trap on *Prunus emarginata*. C.N.C. type number 12574.

Remarks. This species is closely related to *copula*, from which it can be distinguished by the green, unmarked colour and the longer and narrower 2S apodemes. The laterally-directed brachone tip is unique in this species group.

The fact that this specimen was collected on bitter cherry should not be interpreted as indicating that this is the host for the species.

EMPOASCA *(Kybos)* EXIGUAE Ross

Empoasca (Kybos) exiguae Ross, 1963: 220 (new Canadian record).

Unmarked green, with rarer golden-orange form, like that of *albolinea* Gillette (= *digita* DeLong). Collected from: Naramata, Penticton, Similkameen and Summerland: 123 specimens.

Remarks. Parasitized specimens resemble *E. improcera* Ross, which may prove to be synonymous with *exiguae*.

Host: Collected by Ross from *Salix exigua*. Common throughout lower Okanagan Valley on *Salix* sp. Single-brooded; late July to mid-August.

EMPOASCA *(Kybos)* FONTANA Ross

Empoasca (Kybos) fontana Ross, 1963: 223 (new Canadian record).

Unmarked green, females yellow-green, nymphs very deep green; distinctive small, pointed 2S and linear, transverse 3T apodemes. Collected from: Armstrong, Bridesville, Creston, Ewings Landing, and Okanagan Mission: 15 specimens.

Host: recorded by Ross as *Salix* spp., and sucker growth of *Populus balsamifera;* collected only on *Salix* sp. in British Columbia. Single-brooded; August.

EMPOASCA *(Kybos)* Gelbata DeLong & Davidson

Empoasca gelbata DeLong & Davidson, 1936: 225 (new Canadian record).

Yellowish, unmarked, venter greenish and tegmina white; apodemes similar to those of *coronata*, but distinctly longer. Collected from: Armstrong, Kelowna, Penticton, and Salmon Arm; 13 specimens.

Host: collected on *Populus sargentii*, and on sticky board traps in the vicinity of other related species of cottonwood.

EMPOASCA *(Kybos)* INCIDA DeLong

Empoasca incida DeLong, 1931: 21.

Rather small; unmarked, green, apodemes 2S tiny and 3T curvilinear. Collected from: Creston, Kelowna, and Summerland: 12 specimens.

Remarks. This species has a wider host range than other species in the subgenus.

Host; recorded by Ross from both *Salix* and *Populus* spp.; taken in B.C. on both *Populus tremuloides* and cottonwood *(P.* X *sargentii?).* Single-brooded; late July through August.

EMPOASCA *(Kybos)* LUCIDAE Ross

Empoasca clypeata: Beirne, 1956: 60.

Empoasca (Kybos) lucidae Ross, 1963: 216.

Yellowish with the dorsum and tegmina smoky brown, paler on head and down center of each wing. Collected from: Penticton, Caesars, and Ewings Landing: 5 specimens.

Host: recorded by Ross as *Salix lasiandra*. Probably double-brooded; late June to mid-July, and August.

EMPOASCA *(Kybos)* PATULA DeLong

Empoasca patula DeLong, 1931: 22.

Empoasca patula var. *magna* DeLong, 1931: 23.

Bright green unmarked; distinctive 2S apodemes four segments long. Collected from: Armstrong, Robson and Summerland: 20 specimens.

Host: *Salix* sp. Single-brooded; late June through July.

EMPOASCA *(Kybos)* PORTOLA Ross

Empoasca (Kybos) portola Ross, 1963: 215 (new Canadian record).

Large; pale green, often turning pale ochreous on drying; distinctive large 2S and linear 3T apodemes. Collected from: Camp McKinney, Caesars, Okanagan Mission, Penticton, Summerland, and Ewings Landing: 245 specimens.

Described from a pair of specimens collected on *Populus balsamifera.* Commonly on *Populus trichocarpa* in British Columbia, often being abundant on the sucker growth; also on cottonwood *(Populus* X *sargentii?).* Double-brooded; late June to mid-July, and August.

EMPOASCA *(Kybos)* ROSSI n. sp.

(Figs. 9, 17)

Male. Length, 4.6 - 4.9 mm. Colour pale green, unmarked. General structure typical for subgenus. Apodemes 2S very short, 1/3 length of third tergite, strap-shaped, with posterolateral margins recurved. Apodemes 3T very small, lobate, widely separated, lying laterad of 2S; 4T almost as long as fourth tergite, broadly lobate, slightly turned outwards, contiguous but not fused at base. Eighth sternite weakly produced mesally, folded on meson. Anal hook slender and evenly curved cephalad. Brachone parallel-margined, apically flattened and tapered, curved regularly dorsad. Base of plates with very small, fine setae.

Female. Length, 4.8 - 5.1 mm. Colour pale green. Seventh sternite strongly tapered and produced to truncate apex, with small lateral angles.

Types. Holotype, ♂, Powell Beach, Summerland, B.C., 23 June 1971, K. G. A. Hamilton, on *Populus tremuloides.* Allotype, ♀, same data as holotype. Paratypes: 9 ♂♂, 11 ♀♀, same data as holotype; 1 ♂, 3 ♀♀, same data, 5 July 1971; 1 ♂, Summerland, 4-10 August 1971, sticky board trap on choke cherry. C.N.C. type number 12575.

Remarks. The well-developed 4T apodemes ally *rossi* to *gribisa* Ross and *sprita* Ross. These apodemes approximate those of *sprita* in size, but the lobes are well separated. Apodemes 2S are similar to those of *mesolinea* Dav. & DeL., suggesting that the *gribisa* group

is descended from the ancestor in the *trifasciata* group which also gave rise to *mesolinea*.

I take great pleasure in naming this species after Dr. H. H. Ross, both for his work in this subgenus, and for his continued help and encouragement in my studies.

Host: *Populus tremuloides*. Probably double-brooded; late June to early July, and early August.

EMPOASCA *(Kybos)* RUBRATA DeL. & Dav. (Figs. 12, 20)

Empoasca rubrata DeLong & Davidson, 1936: 226.

Yellow with same markings as in *copula*, but those of body redder, giving it a pinkish cast; abdomen not so heavily tanned as in *copula*. Collected from Summerland: 17 specimens.

Remarks. Both parasitized and unparasitized specimens showed essentially the same features of small 2S apodemes and no tergal apodemes, thus demonstrating that this is indeed a distinct species. The specific characters were not illustrated by Ross, and so are figured here.

Host: cottonwood *(Populus* X *sargentii?)*. Collected in August.

EMPOASCA *(Kybos)* TIGRIS n. sp. (Figs. 1, 2, 5, 13)

Male. Length, 3.9 - 4.2 mm. Colour pale yellow, overlaid with black as follows: head, pronotum, and two triangular dashes on scutellum, paling on mid-line and edge of scutellum to fuscous, on lower part of head to sordid yellow; tegmina with transverse band at midlength as wide as pale bands, and apical third solidly marked. General structure typical for subgenus. Apodemes 2S long, extending into fifth segment, parallel-margined and apically subtruncate; apodemes 3T lobate, extending to fourth segment, placed laterad of 2S but not divergent. Eighth sternite as in *rossi*. Anal hook tapered, strongly angled anterodorsad at midlength. Brachone parallel-margined, straight, apically sharply pointed, tip scarcely directed outwards. Base of plates with numerous short, tiny setae.

Female. Length, 4.0 - 4.4 mm. Colour pale yellow, overlaid with fuscous as follows: crown bearing paired discal spots, pronotum bordered on posterior half, scutellum with triangles and paired mesal spots, tegmina with transverse band at midlength narrower than pale bands, and spot behind clavus tip showing pale veins. Seventh sternite roundedly produced between lateral angles.

Types. Holotype, ♂, Powell Beach, Summerland, B.C., 23 June 1970, K. G. A. Hamilton, on *Populus trichocarpa*. Allotype, same data as holotype. Paratypes: 1 nymph, 26 ♂♂, 6 ♀♀, same data as holotype; 8 ♂♂, same data, 21 June 1970; 1 ♂, Summerland, 7-13 July 1971, sticky board on *Cornus* sp.; 2 ♂♂, 3 ♀♀, Summerland, 5 July 1971, K. G. A. Hamilton, on *Populus tremuloides*. C.N.C. type number 12576.

Remarks. This species has the colour pattern of *trifasciata* Gillette, but has distinctly different apodemes and brachone. It resembles *livingstoni* Gillette in genital characters and apodemes, except that the brachone is not swollen apically, and the 2S apodemes do not have dorsal flaps; it differs from this species also in having transverse rather than longitudinal banding. The anal hook is unique.

Unlike most related species, *tigris* feeds on the upper surface of the leaves; it is usually found in association with *portola*, which seldom ventures to the upper side.

Hosts: *Populus trichocarpa* (probably preferred host) and *P. tremuloides*. Single-brooded, late June to mid-July.

EMPOASCA *(Kybos)* TRIFASCIATA Gillette

Empoasca trifasciata Gillette, 1898: 726. (new Canadian record).

Bright green to yellowish-green with irregular fuscous bands as in *tigris*, but lacking markings of crown and scutellum. Collected from Summerland: 4 specimens (no males).

Host: recorded by DeLong (1931) as Carolina poplar *(Populus* X *canadensis)*. I have taken specimens on cottonwood *(Populus* X *sargentii?)*. Probably single-brooded; early August.

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ADDITIONAL RECORDS OF SPIDERS (ARANEIDA) AND HARVESTMEN (PHALANGIDA) FOR BRITISH COLUMBIA

P. D. BRAGG AND R. E. LEECH[1]

ABSTRACT

An annotated list is given of 47 species of spiders and 7 species of harvestment not previously reported in faunal lists from British Columbia.

Nous presentons ici une liste annotée de 47 especes d'araignées et 7 espèces de fauchers qui ne se trouve pas dans l'inventaire de la faune de la Colombie Britannique.

INTRODUCTION

Thorn (1967) recorded 212 species of spiders in British Columbia. The list was compiled from records scattered in the literature and from specimens in the British Columbia Provincial Museum in Victoria. Thorn overlooked two notes by Leech (both 1947) in which there are 13 additional species recorded.

The only harvestmen reported previously for the province are *Homolophus biceps* (Thorell) and *Leiobunum exilipes* (Wood) by Banks (1916), and *Sclerobunus nondimorphicus* Briggs and *Paranonychus brunneus* (Banks) by Briggs (1971).

The purpose of this paper is to present an annotated list of an additional 47 species of spiders and 7 species of harvestmen collected in British Columbia, mostly by the senior author. Harvestmen of the genera *Mitopus* and *Odiellus* also occur (according to Dr. Arlan Edgar, *in litt.*), but due to problems of nomenclature in these genera, they are not included in the list. Most of the specimens were collected in Vancouver. The initials "PDB" used below are those of the senior author. The spiders were identified by Leech, and the phalangids by Bragg.

[1] 4610 West 6th Avenue, Vancouver, B.C., and Entomology Research Institute, Canada Agriculture, Ottawa, respectively.

ARANEIDA

AGELENDAE

Cryphoeca peckhami Simon.

Lighthouse Park, West Vancouver, 4 Sept 1966, PDB, on rock face, 1 ♀. U.B.C. Endowment Land Forest, Vancouver, 16 May 1971, PDB, on alder trunk, 1 ♀. New record for British Columbia. Known also from Oregon and Washington.

Cybaeus conservans Chamberlin and Ivie.

52 mi N.W. Manson Creek, 3200 ft alt, 30 July 1966, R. E. Leech, 1 ♀. New record for British Columbia. Previously known from Oregon.

Cybaeus eutypus Chamberlin and Ivie.

U.B.C. Endowment Land Forest, Vancouver, collected throughout the year as adults, PDB. Roth (1952:212) mentioned one specimen collected near Victoria. Known also from Oregon and Washington.

Tegenaria agrestis (Walckenaer).

Vancouver, 26 July 1962, PDB, webs in grass, 1 ♀. 18 Aug 1963, PDB 2 ♂♂. New record for British Columbia. Introduced to North America from Europe (Roth, 1968:51), and now well established in Oregon, Washington, and Idaho.

AMAURODIIDAE

Amaurobius borealis Emerton.

S.E. of Morley River Lodge (59 57' N,

132 01'W), several specimens. This is a widespread boreal species occurring from northern British Columbia to Newfoundland, and south into the northern parts of the United States (Leech, 1972:73).

Arctobius agelenoides (Emerton).
Manson Creek, Cassiar District, and Ross Lake, Yoho National Park. Distribution Holarctic, widespread in western Canada and Alaska (Leech, 1972:93).

Callioplus euoplus Bishop and Crosby.
Field. Tupper. Boreal, from Newfoundland to western Northwest Territories and British Columbia. Commonly found in leaf litter by pitfall or Berlese funnel methods (Leech, 1972:55).

Callioplus wabritaskus Leech.
Emerald Lake, Yoho National Park; 52 mi. N.W. Manson Creek, Cassiar District. Six Mile Lake, Cassiar District. Mainly coastal Alaska, British Columbia and Washington (Leech, 1972:58).

Callioplus enus (Chamberlin and Ivie).
Invermere, 8000 ft alt. Nelson. Selkirk Mtns, head of Sawmill Creek W. of Wycliff, 6050 ft alt. Summerland. Known also from Washington, Oregon, Idaho and Montana (Leech, 1972:34).

Titanoeca niqrella (Chamberlin).
Many locations in British Columbia (Leech, 1972:96). Widespread in western North America.

Titanoeca silvicola Chamberlin and Ivie.
Many locations in British Columbia (Leech, 1972:98). Holarctic. Known from western North America from Alaska south to Arizona and New Mexico.

Zanomys aquilonia Leech.
Mudge Island, 9 Aug. 1968, PDB, 1 ♀ with egg sac, under log on ground in mixed woodland. Known also from Oregon and Washington (Leech, 1972:89).

CLUBIONIDAE

Castianeira longipalpus (Hentz).
U.B.C. Endowment Land Forest, Vancouver, 24 Aug 1964, PDB, 1 ♂, under rock. Previously known from Vancouver Island (Reiskind, 1969:186). Widespread in North America.

Clubiona mimula Chamberlin.
Vancouver, 16 May 1971, PDB, 1 ♀, in house. New record for British Columbia. Known from the western United States (Edwards, 1958;397).

Clubiona pallidula (Clerck).
Vancouver and Langley, 2 May 1970 and 23 May, 1971, PDB, 2 ♂♂. New record for British Columbia. This is an introduced European species.

DICTYNIDAE

Dictyna bostoniensis Emerton.
Osoyoos, 2 July 1971, PDB, 1 ♀, web on wild rose. New record for British Columbia. Widespread in the United States and southern Canada (Chamberlin and Gertsch, 1958:78).

Dictyna sp. aff. *peon* Chamberlin and Gertsch.
Burns Bog, Delta, 6 June 1971, PDB, 1 ♀, in web on *Spiraea* sp. This is probably a new species.

ERIGONIDAE (=MICRYPHANTIDAE)

Catabrithorax stylifer Chamberlin.
U.B.C. Endowment Land Forest, Vancouver, 26 Oct 1969, PDB, 3 ♂♂, on low herbage. Widespread in western North America from Alaska to California, east to Idaho and Utah.

Centromerus sylvaticus (Blackwall).
Vancouver, 1 Jan 1961, PDB, 1 ♀, woodpile in garden. Widespread, Holarctic. Common in grassy and mossy areas.

Cheraira willapa Chamberlin.
U.B.C. Endownment Land Forest, Vancouver, many records from late December to mid April, PDB, in leaf litter. New record for British Columbia. Known previously from northwestern Washington state. *Cheraira* may be a synonym of *Caledonia*.

Coreorgonal monoceros (Simon).
U.B.C. Endownment Land Forest, Vancouver, many records, all male, from early November to late March, PDB, in leaf litter. New record for British Columbia. A winter species, rarely collected previously. Known also from western Washington and Oregon (Bishop and Crosby, 1935:219-220).

Erigone aletris Crosby and Bishop.
U.B.C. Endownment Land Forest, Vancouver, 26 Oct 1969, PDB, on low herbage, 2 ♂♂. New record for British Columbia. A coastal species previously known only from the east coast of North America from New York to Maine.

Erigone sp. aff. *dentigera* O. Pickard-Cambridge.
Stanley Park, Vancouver, 21 June 1970, PDB, 1 ♂. New record for British Columbia. *E. dentigera* is widespread from New York to Montana. The genus *Erigone* is much in need of revision. The specimen at

hand does not quite match the description of *E. dentigera*, and it is either a clinal variant or a new species.

Erigone metlakatla Crosby and Bishop.
U.B.C. Endownment Land Forest, Vancouver, 26 Oct 1969, PDB, 1♂, on low herbage. Previously known from Metlakatla, but is probably distributed in the coastal area from Alaska to Oregon.

Sisicottus montanus (Emerton).
U.B.C. Endownment Land Forest, Vancouver, many records from late February to late June, PDB, in leaf litter. This species is polymorphic, or else several species are placed under this name. Bishop and Crosby (1938:58-60) have commented on the variation. Assuming only one species is present, it is found widespread in North America from Alaska to Labrador and as far south as Wyoming and New York.

Wubana pacifica (Banks).
U.B.C. Endownment Land Forest, Vancouver, 29 Nov 1969, PDB, 1♂, in leaf litter. Previously known from Larabee Park, Washington, and Lake Cameron, Vancouver Island. It is also recorded from New York state (Chamberlin and Ivie, 1936:90-91).

GNAPHOSIDAE (=DRASSIDAE)

Drassyllus depressus (Emerton).
Langley, 23 May 1971, PDB, 1♀, in dry, grassy field. New record for British Columbia. Widespread in North America.

Micaria pulicaria (Sundevall)
Burnaby Mtn, 3-14 Aug 1971, R. G. Holmberg, in pitfall traps, 1♂ 2♀♀. New record for British Columbia. Widespread Holarctic.

LINYPHIIDAE

Bathyphantes orica Ivie.
U.B.C. Endownment Land Forest, Vancouver, 12 July 1969, PDB, 1♂. 7 Sept 1969, PDB, 1♀, in pitfall trap. Ivie (1969) recorded this species from the Pacific coast area from San Francisco to southern British Columbia.

Drapetisca alteranda Chamberlin.
U.B.C. Endownment Land Forest, Vancouver, Several records during August and September, PDB, on alder and conifer trunks. New record for British Columbia. Widespread Nearctic from Alaska southeast to central and eastern United States and Canada.

Lepthyphantes tenuis (Blackwall).
Haney, 5 June 1965, PDB, 1♀, U.B.C. Endownment Land Forest, Vancouver, February and September, PDB, 2♀♀, collected in pitfall traps and on low vegetation. New record for British Columbia. Previously known from Europe.

Lepthyphantes leprosus (Ohlert).
Vancouver, 13 Oct 1970, PDB, 1♀, in house. Widespread Holarctic.

Lepthyphantes zebra Emerton.
U.B.C. Endowment Land Forest, Vancouver, 25 Sept 1965, PDB, 1♂. Widespread Nearctic from Alaska to North Carolina. From British Columbia, previously recorded from Aleza Lake and Terrace. (Zorsch, 1937:890).

Lepthyphantes zelatus Zorsch.
U.B.C. Endowment Land Forest, Vancouver, many records from November to April, PDB, in leaf litter. New record for British Columbia. Known also from Sol Duc Hot Springs, Olympic National Park, Washington (Zorsch, 1937:895).

Microlinyphia dana (Chamberlin and Ivie).
U.B.C. Endowment Land Forest, Vancouver, many records from early June to August. One mating pair collected 29 June 1965, PDB. Helsdingen (1970:50) reported this species from Wellington, Vancouver Island. Known also from Laguna Beach, California, north to Alaska (Chamberlin and Ivie, 1943:25-26; and Chamberlin and Ive, 1947:61).

Microneta viaria (Blackwall).
U.B.C. Endowment Land Forest, Vancouver, 27 Sept 1970, PDB, 1♀, in leaf litter. Usually found in detritus and leaf litter. Widespread Holarctic. Apparently a new record for British Columbia.

LYCOSIDAE

Pardosa altamontis Chamberlin and Ivie.
U.B.C. Endowment Land Forest, Vancouver, 4 July 1965, PDB, 1♀, under log. New record for British Columbia. Known from northwestern United States (Chamberlin and Ivie, 1946:7-8).

Pardosa diuturna Fox.
Subalpine meadow, Diamond Head Lodge, Garibaldi Park, 22 Aug 1969, PDB, 1♀ and egg sac. New record for British Columbia. Known previously from the Muir Glacier, Alaska (Fox, 1937:114; and Chamberlin and Ivie, 1947:19).

Pardosa uncata (Thorell).
Vancouver, Burnaby Mtn, 13 June 1971, J. M. Hardman. Many males and females.

New record for British Columbia. This species has long been confused with *Pardosa mackenziana* and *P. uintana*. Previously known from the montane regions of western North America.

PHOLCIDAE

Pholcus phalangioides (Feusslin).

Vancouver, 9 Oct 1963, PDB, 1 ♀, in house. Synanthropic. Widespread temperate.

TETRAGNATHIDAE

Tetragnatha caudata Emerton.

Chilliwack, 1 June 1963, PDB, 1♀, on log. New record for British Columbia. Widespread from British Columbia to Maine, south to Florida.

Tetragnatha straminea Emerton.

Vancouver, 5 July 1970, PDB, 1 ♀, in web at lakeshore. New record for British Columbia. Distributed approximately as *T. caudata*.

THERIDIIDAE

Robertus vigerens (Chamberlin and Ivie).

U.B.C. Endownment Land Forest, Vancouver, many records from March to September, PDB, in pitfall traps, leaf litter, etc. Kaston (1946) recorded this species from numerous places in Alaska, British Columbia, Washington, Oregon, California, Idaho, Montana, and Utah. We have also seen specimens from Twin Lakes, Waterton National Park, Alberta, collected on 30 June 1969, by D.R. and G.J. Whitehead (1♂, 4 ♀♀).

Theridion bimaculatum (Linnaeus).

Burns Bog, Delta, 6 June 1971, PDB, 1♂. U.B.C. Endowment Land Forest, Vancouver, 7 Sept 1963, PDB, 1 ♀; and 19 July 1964, PDB, 2 ♀♀ with egg sacs, on low shrubs. Levi (1956: 409-412) recorded this species from Wellington, Vancouver Island. Known also from Washington state. The distribution suggests that this is a species recently introduced from Europe, where it is well known.

Theridion varians Hahn.

U.B.C. Endowment Land Forest, Vancouver, 26 Aug 1965, PDB, 1♀. Levi (1957:52-53) recorded this species from Vancouver. In North America, also known from Washington state. Again, probably an introduced species.

THOMISIDAE

Ebo pepinensis Gertsch.

Reported from Vancouver Island and known from western North America as far east as Ontario and Illinois (Sauer and Platnick, 1972:43-44).

Thanatus patriciae (Lowrie and Gertsch).

Alpine meadow, Blackwall Mtn, Manning Provincial Park, 3 July 1970, PDB, 1♂. New record for British Columbia. Previously known from Colorado, Idaho, Montana, and Wyoming. It is a high altitude species (Dondale, Turnbull and Redner, 1964:654-655).

PHALANGIDA

ISCHYROPSALIDAE

Sabacon crassipalpe (L. Koch).

U.B.C. Endowment Land Forest, Vancouver, June to October, PDB. Collected under logs and in leaf litter by pitfall traps. New record for British Columbia. Widespread Holarctic.

NEMASTOMATIDAE

Nemastoma modesta Banks.

U.B.C. Endowment Land Forest, Vancouver, immatures found throughout the year, adults from May to August, PDB, commonly collected by pitfall traps in leaf litter. New record for British Columbia. Known also from California and Washington.

PHALANGIIDAE

Phalanguim opilio Linnaeus.

Vancouver. Chilliwack. Vernon. Parksville. Many males and females and immatures found frequently between April and October. PDB. Widespread Holarctic. Probably overwinters as egg. First very small immatures seen in early April. Does not overwinter as adult. First matures seen in June. Eggs deposited from August to September. One female at Parksville laid 195 eggs on September 22, 1967 (PDB).

TRIAENONYCHIDAE

Paranonychus brunneus (Banks).

U.B.C. Endowment Land Forest, Vancouver. Burnaby. Collected throughout the year, PDB, under logs and in leaf litter. Known from British Columbia, Alaska, Oregon and Washington (Briggs, 1971:13-14). Probably overwinters as adults with eggs hatching in spring.

Sclerobunus nondimorphicus Briggs.

10.6 Mi. E. Hope, near Manning Provincial Park, and 17.8 Mi. E. Hope, near Manning Provincial Park (Briggs, 1971:9-10).

TROGULIDAE

Dendrolasma mirabilis Banks.

U.B.C. Endowment Land Forest, and Stanley Park, Vancouver, several records,

March through September, PDB. A leaf litter species often collected under logs. Known also from Oregon and Washington.

Ortholasma pictipes Banks.

U.B.C. Endowment Land Forest, Vancouver, collected throughout the year, PDB, in pitfall traps and in leaf litter. May overwinter as immature. Adults found from March to October. Known also from California.

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THE IMMATURE STAGES OF *GERRIS* (HEMIPTERA) IN BRITISH COLUMBIA

G. G. E. Scudder and G. S. Jamieson[1]

ABSTRACT

The immature stages of seven species of **Gerris** that occur in British Columbia are described and keyed.

INTRODUCTION

Eight species of *Gerris* are recorded from British Columbia and several of these appear to coexist, since they can be captured together at the same place and at the same time (Scudder, 1971). In order to study this apparent coexistence in some detail, it is necessary to be able to identify the species in all of their life stages. While the fifth instar larvae of *G. buenoi* Kirk., *G. comatus* D. & H. and *G. remigis* Say have been described by Sprague (1967), the other larvae that occur in British Columbia are unknown.

This paper describes the five immature instars of seven species of *Gerris* that occur in British Columbia, gives diagnostic keys and some figures. *G. nyctalis* D. & H. was not available for study and so could not be included.

MATERIAL AND METHODS

Adult *Gerris* were brought into the laboratory in the spring and summer of 1970 and 1971, and cultures of each species were established. Adult *G. buenoi*, *G. incognitus* D. & H., *G. incurvatus* D. & H., *G. notabilis* D. & H. and *G. remigis* were obtained from Marion Lake near Haney in the lower Fraser Valley. *G. pingreensis* D. & H. was collected from a lake on the Batchelor Range north of Kamloops and *G. comatus* from a pond near Westwick Lake in the Cariboo region.

All rearing was done at laboratory temperature (about 22°C) and with natural photoperiod. Food was frozen adult *Drosophila*. Eggs that were obtained from the isolated adults, were kept separate and the emerging larvae were held in small plastic containers. They were fed each day and larvae of each instar as obtained were preserved in 70 per cent alcohol. All measurements were done by use of a graticule eye-piece and are based on five specimens unless otherwise stated. Standard errors have been calculated on the values presented in Table 1 and are available from the authors on request: the Table would be too large if they were included in this publication.

The keys and values presented in Table 1 have been checked against material that we have collected from the field.

[1]Department of Zoology, University of British Columbia, Vancouver.

RESULTS

The diagnotic measurements for the larvae studied are presented in Table 1. The colour patterns are distinctive in most instars and species. The following descriptions record the important features.

G. buenoi

FIRST INSTAR (Fig. 3): head brown-black with pale Y-shaped dorsal ecdysial cleavage line; antennae brown-black with base of first segment pale; rostrum pale with apex black; pronotum with lateral quadrate patches; posterior part of mesonotum + metanotum with a lateral oblong fuscous patch; mid and hind coxal covers brown-black; fore legs brown-black with femora, trochanters and coxae pale; middle and hind legs brown-black with base of trochanters and all of coxae pale; abdominal terga with medio-lateral slender transverse streaks, the anterior ones narrower than the posterior; anal cover fuscous.

SECOND INSTAR (Fig. 8): as first instar, but with clypeus and postocciput slightly pale; mesonotal patch with centre pale; coxal covers pale; anterior abdominal markings not narrower than posterior.

THIRD INSTAR (Fig. 12): as second instar, but with clypeus quite pale; area of postocciput adjacent to stem of cleavage line, pale; mesonotum with pale area adjacent to anterior of fuscous patch and this connected to anterior margin of mesonotum by a thin pale line; patch on mesonotum posteriorly pale; abdominal terga with a pale outline to posterior of medio-lateral fuscous spots, and with a series of pale spots also present lateral to the fuscous series.

FOURTH INSTAR (Fig. 16): head anteriorly rather pale with fuscous spots at base of the four trichobothria; pronotum with the patch sometimes pale postero-laterally; mesonotum medially brown with a median pale arrow-

TABLE I. Diagnostic measurements for the larval instars of **Gerris** species in British Columbia. Mean values in mm.

Species & instar	Antennal segment I	II	III	IV	Head width	Middle leg Femur	Tibia	Tarsus	Hind leg Femur	Tibia	Tarsus	Sample size
buenoi												
First	0.17	0.10	0.13	0.43	0.44	0.65	0.81	0.71	0.61	0.42	0.35	5
Second	0.29	0.17	0.20	0.56	0.60	1.06	1.17	0.91	0.98	0.58	0.46	5
Third	0.40	0.26	0.30	0.70	0.83	1.69	1.68	1.26	1.59	0.85	0.58	5
Fourth	0.60	0.40	0.40	0.77	1.00	2.61	2.36	1.87	2.44	1.24	0.74	5
Fifth	0.76	0.49	0.52	0.97	1.18	3.69	3.15	2.57	3.48	1.80	1.01	5
comatus												
First	0.15	0.12	0.12	0.42	0.45	0.75	0.86	0.69	0.63	0.46	0.43	3
Second	0.25	0.13	0.20	0.53	0.61	1.24	1.34	1.09	1.12	0.71	0.58	2
Third	0.43	0.27	0.30	0.63	0.87	2.00	1.97	1.57	2.00	1.10	0.73	1
Fourth	0.66	0.40	0.40	0.74	1.02	3.18	2.74	1.85	2.95	1.62	0.96	2
Fifth	1.02	0.56	0.55	0.87	1.34	4.95	3.82	2.98	4.62	2.58	1.55	3
incognitus												
First	0.20	0.13	0.17	0.43	0.48	0.69	0.83	0.71	0.61	0.48	0.40	5
Second	0.27	0.17	0.20	0.53	0.63	1.16	1.22	0.94	1.03	0.70	0.50	5
Third	0.34	0.20	0.28	0.65	0.83	1.79	1.60	1.27	1.57	0.96	0.68	5
Fourth	0.60	0.33	0.40	0.80	1.01	2.70	2.25	1.62	2.52	1.43	0.83	5
Fifth	0.83	0.50	0.53	0.92	1.25	3.73	3.00	2.09	3.55	2.00	1.08	5
incurvatus												
First	0.20	0.13	0.17	0.42	0.49	0.76	0.96	0.81	0.67	0.52	0.42	5
Second	0.26	0.17	0.20	0.53	0.59	1.25	1.33	1.09	1.13	0.71	0.56	5
Third	0.42	0.26	0.30	0.63	0.83	2.10	2.00	1.50	1.90	1.06	0.69	5
Fourth	0.65	0.40	0.45	0.76	1.01	3.17	2.73	2.07	2.92	1.57	0.94	5
Fifth	0.97	0.60	0.62	0.87	1.27	4.64	3.81	2.83	4.31	2.64	1.37	5
notabilis												
First	0.23	0.17	0.20	0.59	0.52	1.06	1.29	1.04	0.96	0.59	0.51	5
Second	0.39	0.30	0.33	0.82	0.79	1.78	1.78	1.49	1.68	0.94	0.65	5
Third	0.68	0.54	0.54	1.11	1.08	3.16	2.85	2.24	2.96	1.63	0.90	5
Fourth	1.07	0.82	0.79	1.32	1.37	4.84	4.20	3.16	4.84	2.84	1.42	5
Fifth	1.88	1.43	1.16	1.58	1.81	7.88	6.18	4.56	8.14	5.10	2.06	5
pingreensis												
First	0.20	0.17	0.13	0.40	0.47	0.67	0.77	0.67	0.60	0.47	0.40	1
Second	0.26	0.17	0.20	0.46	0.63	1.09	1.07	0.92	0.94	0.64	0.54	2
Third	0.43	0.23	0.27	0.60	0.83	1.67	1.57	1.13	1.53	0.97	0.77	1
Fourth	0.54	0.36	0.40	0.78	1.04	2.61	2.31	1.78	2.51	1.47	0.96	2
Fifth	0.86	0.46	0.50	0.86	1.24	3.75	3.30	2.53	3.65	2.15	1.33	2
remigis												
First	0.23	0.13	0.21	0.45	0.58	1.14	1.35	1.08	1.07	0.72	0.54	5
Second	0.38	0.20	0.32	0.58	0.82	1.97	2.04	1.41	1.81	1.09	0.66	5
Third	0.56	0.34	0.46	0.72	1.12	3.29	3.14	1.98	2.87	1.87	0.93	5
Fourth	0.92	0.49	0.65	0.88	1.44	5.02	4.68	2.64	4.66	3.26	1.32	5
Fifth	1.50	0.76	0.89	1.13	1.77	7.48	6.62	3.34	6.66	5.10	1.82	5

shaped mark; pale area to base of wing buds forming a W-shaped mark or at least with a pair of slender pale lines connecting to anterior margin of mesonotum; stem of arrow on mesonotum brown, the head fulvous; centre of anterior abdominal terga with a median brown line; pale and fuscous spots as in third instar; fore tarsi quite black.

FIFTH INSTAR (Fig. 21): head brown black with clypeus black, paraclypeal lobes pale; frons with centre pale, and with four fuscous spots, two on each side; vertex with Y-shaped pale line; pronotum black with central longitudinal pale line; mesonotum with a central, posteriorly pointing arrow, the head fulvous and shaped as in Fig. 26, the stem brown margined with white; mesonotum antero-laterally with posteriorly pointing small arrow-shaped white mark; abdominal dorsum fuscous with markings as in previous two instars; legs and antennae coloured as in adult.

G. comatus

FIRST INSTAR: coloration as in first instar of *G. buenoi*, with markings on anterior abdominal terga narrower than those on posterior terga; markings on posterior terga slightly quadrate.

SECOND INSTAR: as in first instar; head with frons and vertex medially and laterally rather pale; centre of pronotal patches sometimes pale; mesonotal patches fuscous only in centre; mesonotal patches surrounded by pale lines and each connected to anterior margin of mesonotum by a thin white line;

abdominal fuscous spots about same size on all terga, surrounded by white outline posteriorly; with vague series of pale spots laterally to fuscous series.

THIRD INSTAR: Markings as in second instar with the pale outline to mesonotal patches broader; mesonotum without an obvious arrow-shaped mark; abdominal terga with lateral pale spots distinct.

FOURTH INSTAR (Fig. 18): head fuscous with a central pale streak to frons that extends to clypeus, and vertex with lateral pale longitudinal streaks that extend forwards: pronotum with a central longitudinal brown line outlined with white; mesonotum with a central arrow-shaped mark, the stem brown margined with white, the head with narrow arms; fuscous areas on mesonotum with pale region adjacent anteriorly and this connected to anterior margin of mesonotum by a pale line; abdominal fuscous spots rather large and about same size, margined with white and with a series of pale spots laterally.

FIFTH INSTAR (Fig. 22): head marked much as in fourth instar; mesonotum with a medium arrow-shaped mark, the stem with a brown centre basally, the head with shape as in Fig. 24; abdominal markings similar to fourth instar.

G. incognitus

FIRST INSTAR (Fig. 1): coloration as in first instar of *G. buenoi*, but with markings on abdominal terga about same size on all segments and rather quadrate.

SECOND INSTAR (Fig. 6): as first instar, but vertex slightly pale; mesonotal patch somewhat pale postero-laterally.

THIRD INSTAR (Fig. 10): basal three antennal segments pale basally; centre of frons with two longitudinal pale streaks; clypeus pale; mesonotal patches with C-shaped pale mark dividing fuscous area into two; fuscous spots on abdominal terga with pale outline posteriorly.

FOURTH INSTAR (Fig. 14): similar to third instar, but with pale lines on frons continuous on vertex; mesonotum with a median longitudinal brown streak outlined with white; mesonotum with an oblique pale streak through middle of fuscous patches, these oblique streaks connected to anterior margin of mesonotum by a thin pale line; centre of mesonotum with an arrow-shaped mark, the head shape similar to Fig. 27; anterior abdominal terga with small fuscous spot to outside of medio-lateral markings.

FIFTH INSTAR (Fig. 19): head with markings as in fourth instar; frons with additional fuscous spots laterally; pronotum black with a median longitudinal pale streak; mesonotum black with a median arrow-shaped mark, the stem brown margined with white, the head shaped as in Fig. 27; mesonotum antero-laterally with pale C-shaped markings; abdominal terga with markings similar to fourth instar; legs and antennae coloured as in adult.

G. incurvatus

FIRST INSTAR (Fig. 2): coloration as in first instar of *G. buenoi*, the anterior abdominal terga with markings narrower than on posterior terga; markings on posterior terga somewhat irregularly quadrate.

SECOND INSTAR (Fig. 7): as first instar, but with clypeus and centre of frons pale; mesonotal patches with only centre fuscous; metanotal and abdominal fuscous markings margined with white posteriorly.

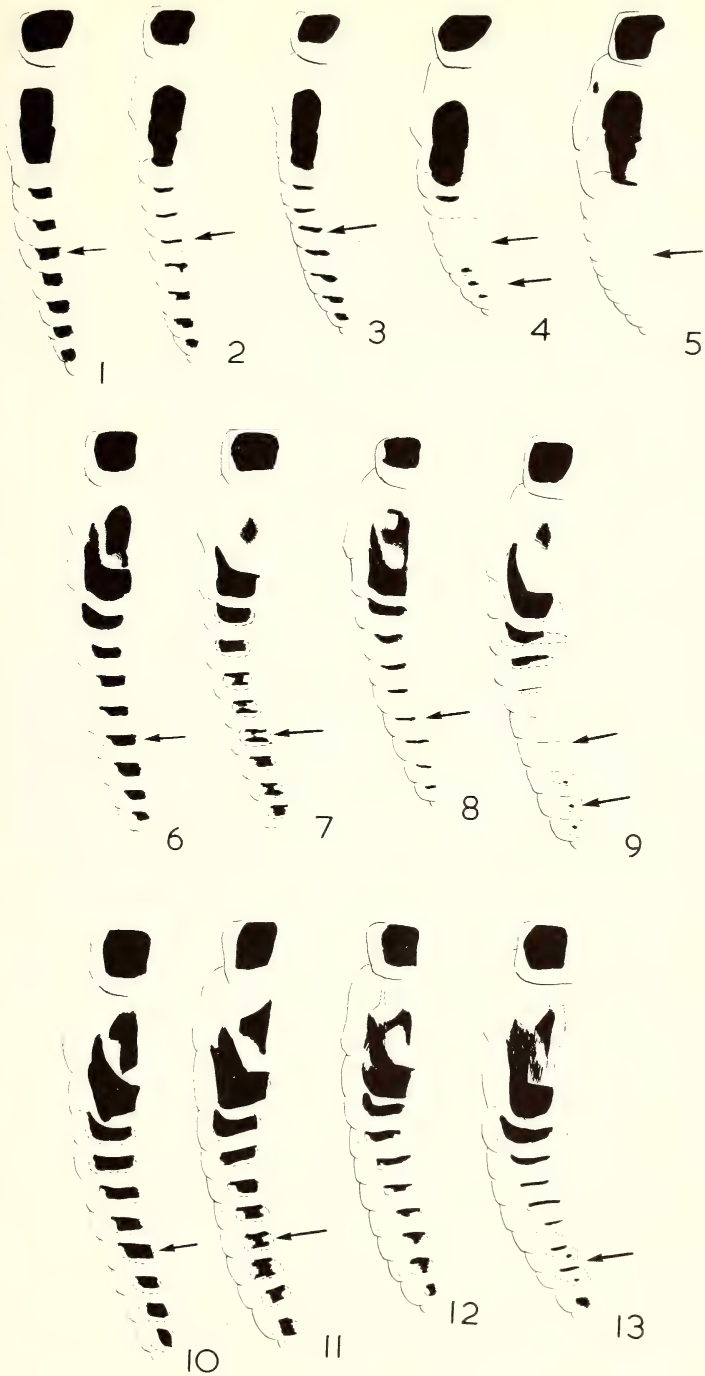
THIRD INSTAR (Fig. 11): as second instar, but head fuscous only behind eyes, at base of trichobothria and as two longitudinal streaks on vertex; pronotal patches sometimes slightly pale laterally; mesonotal patches fuscous only in centre, and mesonotum with apex of wing buds fuscous or with an oval fuscous mark; abdominal terga with a series of pale spots lateral to the medio-lateral fuscous series.

FOUR INSTAR (Fig. 15): as third instar; pronotum brown with the fuscous patches outlined postero-medially with white; mesonotum with a median arrow-shaped mark, the stem brown margined with white, the head fulvous with shape similar to Fig. 25; mesonotal patches antero-laterally pale with a white line extending to anterior margin of mesonotum; wing buds black; abdominal markings as in third instar.

FIFTH INSTAR (Fig. 20): head pale with centre of frons and vertex black, except for a median longitudinal pale streak and four pale spots, two on each side of the pale streak; pronotum black with a median longitudinal pale line; mesonotum black with a median arrow-shaped mark, the head shaped as in Fig. 25, the stem brown margined with fulvous; mesonotum often with small antero-lateral pale spot; abdominal dorsum coloured as in fourth instar; legs and antennae coloured as in adult.

G. notabilis

FIRST INSTAR (Fig. 5): coloration as in first instar of *G. buenoi*, but with metacoxal covers only slightly fuscous, and abdominal



Figs. 1-13. Left side of thoracic and abdominal dorsum of **Gerris** larvae showing colour pattern: 1, **G. incognitus,** first instar; 2, **G. incurvatus,** first instar; 3, **G. buenoi,** first instar; 4, **G. remigis,** first instar; 5, **G. notabilis,** first instar; 6, **G. incognitus,** second instar; 7, **G. incurvatus,** second instar; 8, **G. buenoi,** second instar; 9, **G. remigis,** second instar; 10, **G. incognitus,** third instar; 11, **G. incurvatus,** third instar; 12, **G. buenoi,** third instar; 13, **G. remigis,** third instar. Not to same scale.

terga without fuscous markings.

SECOND INSTAR: Head brown-black with Y-shaped dorsal ecdysial cleavage line quite pale, and lateral areas of vertex pale and centre with a pale stripe, this central pale stripe continued all down body; pronotum with lateral areas only margined with fuscous; mesonotum with vague lateral longitudinal pale and fuscous streaks close together; abdominal terga without distinct markings other than the central pale stripe.

THIRD INSTAR: Instar longitudinally striped and similar to second instar; first and second antennal segments basally pale; body dorsally with central pale longitudinal stripe margined with brown; pronotum margined with brown; mesonotum anteriorly with on each side, two lateral pale stripes separated by a brown streak; abdominal dorsum with vague medio-lateral longitudinal brown streaks; femora pale with dorsal fuscous streak.

FOUR INSTAR: coloration as in third instar, but with third antennal segment also medially pale; body with dorsal longitudinal streaks more distinct, with an additional pale streak laterally on pronotum and mesonotum.

FIFTH INSTAR: head brown-black with pale Y-shaped ecdysial line, lateral pale streak before eyes and a median pale longitudinal line, the latter continued down centre of thorax and as a vague broken line down centre of abdominal dorsum; wing buds black; mesonotum with medio-lateral brown stripe; abdominal terga anteriorly with pale medio-lateral spots.

G. pingreensis

FIRST INSTAR: coloration as in first instar of *G. buenoi*, but with fuscous patches on abdominal terga large and rather like those of *G. incognitus*.

SECOND INSTAR: as first instar, but with lateral areas of vertex pale; frons with medio-lateral pale stripes; mesonotal patches fuscous in centre, surrounded by pale line and then connected to anterior margin of mesonotum by a thin pale line; markings on abdominal dorsum circled with white.

THIRD INSTAR: markings as in second instar, and with small black spot on anterior terga lateral to the larger fuscous markings.

FOURTH INSTAR: similar to third instar; head brown with pale Y-shaped ecdysial cleavage line and four pale spots on frons; pronotum brown with the fuscous patches narrowly margined with white postero-medially; mesonotum with the fuscous patches narrowly margined with white, the centre of the mesonotum appearing as a brown line margined with white; mesonotum without an obvious arrow-shaped mark; abdominal dorsum brown, the fuscous patches large, narrowly margined with white and very distinct.

FIFTH INSTAR (Fig. 23): similar to fourth instar; mesonotum with central brown line narrowly margined with white; mesonotum laterally with a small pale anterior dash; medio-laterally mesonotum quite black, without a distinct arrow-shaped mark; abdominal markings distinct.

G. remigis

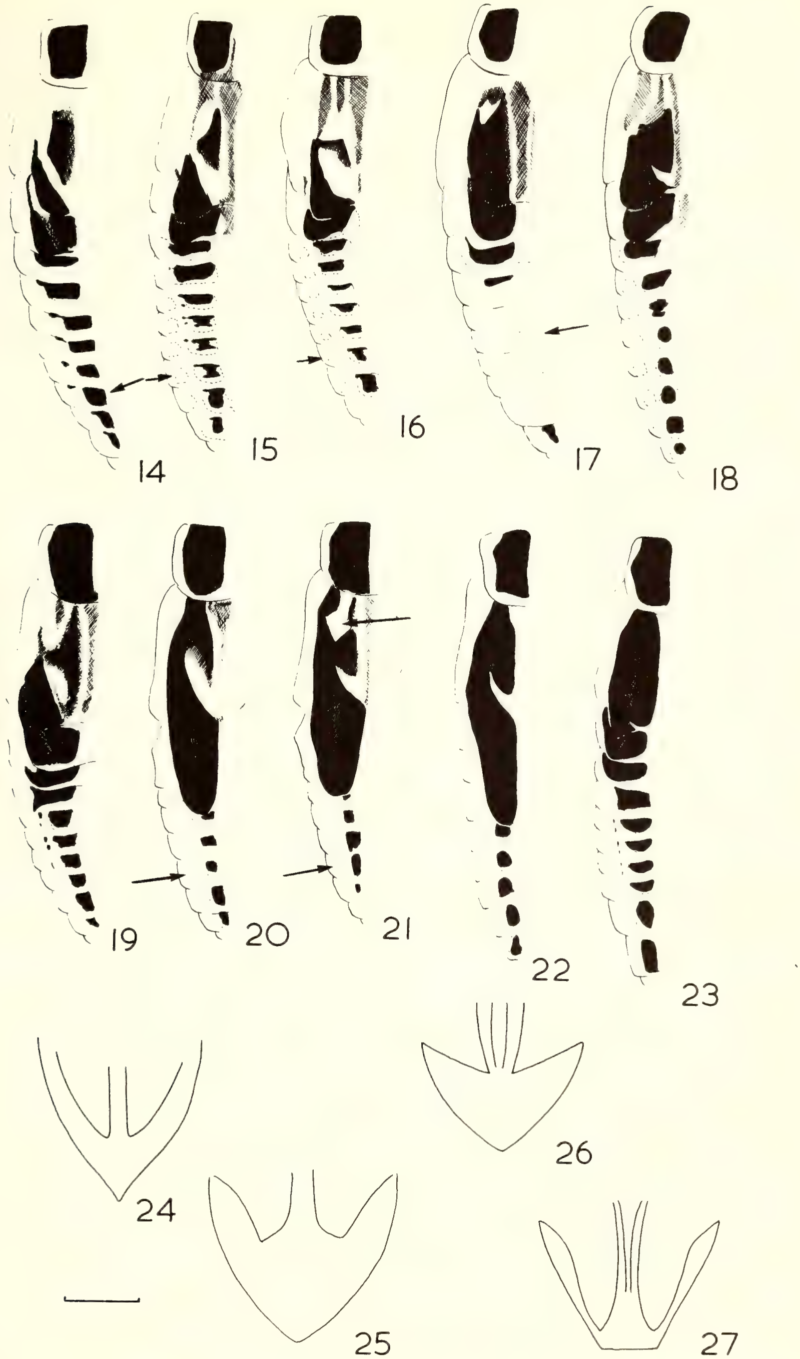
FIRST INSTAR (Fig. 4): coloration as in first instar of *G. buenoi*, but dorsum generally more brownish; anterior abdominal terga without fuscous markings, four of the posterior terga only with small medio-lateral black spots.

SECOND INSTAR (Fig. 9): as first instar, but with clypeus pale and with lateral parts of frons and vertex somewhat pale; mesonotum with a small oval fuscous spot on each side; metanotum and first visible abdominal tergum with the fuscous markings margined with white; anterior abdominal terga in general with very narrow fuscous streaks at junction of terga, and at most with only a vague pale area surrounding these marks; three of posterior terga only with distinct oval pale patches, these usually with a very small central black point.

THIRD INSTAR (Fig. 13): coloration as in second instar, but with mesonotal patches larger and more or less triangular, and with pale more or less whitish streaks along the anterior and median sides of the triangle; lateral margins of mesonotal wing buds narrowly fuscous with ferruginous area between this and the triangular spot; abdominal tergum before anal tube with a pair of fuscous patches; other abdominal terga marked as in second instar, but markings more distinct.

FOUR INSTAR (Fig. 17): coloration as in third instar, centre of mesonotum with a central longitudinal olive coloured stripe margined with dark brown; pale markings on median abdominal terga not always clearly evident.

FIFTH INSTAR: coloration much the same as fourth instar, but head with base of paraclypeal lobes slightly pale, and with a distinct pale spot before each eye; mesonotum black with a more or less distinct central arrow-shaped mark, the stem brown margined with white, the head vague and brown; mesonotum



Figs. 14-23. Left side of thoracic and abdominal dorsum of **Gerris** larvae showing colour pattern: 14, **G. incognitus,** fourth instar; 15, **G. incurvatus,** fourth instar; 16, **G. buenoi,** fourth instar; 17, **G. remigis,** fourth instar; 18, **G. comatus,** fourth instar; 19, **G. incognitus,** fifth instar; 20, **G. incurvatus,** fifth instar; 21, **G. buenoi,** fifth instar; 22, **G. comatus,** fifth instar; 23, **G. pingreensis,** fifth instar. Figs. 24-27. Outline of arrow head-shaped mark on mesonotum of fifth instar larvae of **Gerris:** 24, **G. comatus:** 25, **G. incurvatus;** 26, **G. bueno;** 27, **G. incognitus.** Figs. 14-23 not to same scale. Scale line for Figs. 24-27 = 0.3 mm.

antero-laterally with pale dashes; legs and antennae coloured as in adult.

KEY TO LARVAL INSTARS OF *GERRIS* SPECIES IN BRITISH COLUMBIA

Key to instars

1. —Wing buds long and fore wing buds completely overlapping hind wing buds; if wing buds not completely overlapping head width 1.15 mm. or more[2] .... Fifth instar
—. Wing buds absent, or if present, then not overlapping 2
2. Wing buds distinct, the postero-lateral corners of mesonotum somewhat produced caudad 3
—. Wing buds not present, the postero-lateral corners of mesonotum not produced caudad 4
3. Wing buds visible, but not greatly extended caudad .... Third instar
—. Wing buds clearly evident and obviously extended caudad .... Fourth instar
4. Mesonotum + metanotum laterally with a single oblong-oval fuscous mark on each side; head width usually 0.58 mm. or less . ... First instar
—. Mesonotum + metanotum laterally with disjunct fuscous markings; head width usually over 0.59 mm .... Second instar

To date we have not been able to separate the early instars of **G. comatus** from those of **G. incurvatus**, and **G. incognitus** from **G. pingreensis**. However, in British Columbia they may be separated on geography. It seems that the members of these two pairs of species replace each other geographically. Thus **G. comatus** and **G. pingreensis** occur in the Cariboo area and to the north, while **G. incognitus** and **G. incurvatus** are found to the south (Scudder, 1971).

Key to first instar larvae

1. Middle tibiae over 1.0 mm. in length 2
—. Middle tibiae less than 1.0 mm. in length 3
2. Abdominal dorsum without fuscous markings; length of fourth antennal segment greater than width of head .... **notabilis**
—. Posterior abdominal terga with medio-lateral fuscous markings; length of fourth antennal segment less than width of head . ... **remigis**
3. Medio-lateral black markings on abdominal terga quadrate and all about same size .... **incognitus + pingreensis**
—. Medio-lateral black markings on abdominal terga not all quadrate and all about same size, anterior narrower than posterior 4
4. Posterior markings somewhat quadrate, but irregular .... **comatus + incurvatus**
—. Posterior markings less quadrate, but regular .... **buenoi**

Key to second instar larvae

1. Head width over 0.75 mm.; middle femur over 1.75 mm 2
—. Head width less than 0.70 mm.; middle femur less than 1.50 mm. 3
2. Dorsum of insect with median pale and other longitudinal stripes ...... **notabilis**
—. Dorsum of insect without longitudinal stripes .... **remigis**
3. Medio-lateral markings on abdominal terga all slender and getting gradually smaller from anterior to posterior . . **buenoi**
—. Medio-lateral markings on abdominal terga not slender and getting gradually smaller from anterior to posterior 4
4. Medio-lateral black markings on abdominal terga all regularly quadrate and very distinct, not in obvious pale spots .... **incognitus + pingreensis**
—. Medio-lateral black markings on abdominal terga irregular in outline and usually in rather distinct pale spots .... **comatus + incurvatus**

Key to third instar larvae

1. Head with 1.0 mm. or more; middle femur 2.75 mm. or more 2
—. Head width less than 0.9 mm.; middle femur less than 2.5 mm. 3
2. Dorsum with longitudinal stripes .... **notabilis**
—. Dorsum not longitudinally striped .... **remigis**
3. Abdominal dorsum with a lateral series of pale spots to outside of medio-lateral fuscous series 4
—. Abdominal dorsum without a lateral series of pale spots to outside of the medio-lateral fuscous series .... **incognitus + pingreensis**
4. Anterior medio-lateral fuscous markings on

[2]Fourth instar **G. notabilis** and **G. remigis** will key out at this point, but are readily recognized on size and colour pattern.

abdominal dorsum narrow and not quadrate; .... **buenoi**

—. Anterior medio-lateral fuscous markings on abdominal dorsum rather quadrate and not slender .... **comatus + incurvatus**

Key to fourth instar larvae

1. Head width 1.30 mm. or more; middle femur 4.5 mm. or more 2

—. Head width less than 1.20 mm.; middle femur 3.5 mm. or less 3

2. Dorsum longitudinally striped .. **notabilis**

—. Dorsum not longitudinally striped .... **remigis**

3. Abdominal dorsum with a lateral series of pale spots to outside of medio-lateral series of fuscous markings 4

—. Abdominal dorsum without a lateral series of pale spots to outside of medio-lateral series of fuscous markings 6

4. Anterior medio-lateral fuscous markings on abdominal dorsum narrow and not quadrate; mesonotum with double pale lines connecting pale area round mesonotal patch with anterior margin of notum .... **buenoi**

—. Anterior medio-lateral fuscous markings on abdominal dorsum rather quadrate, and not narrow 5

5. Arrow-shaped mark on mesonotum with head shaped similar to Fig. 24 ... **comatus**

—. Arrow-shaped mark on mesonotum with head shaped similar to Fig. 25 .. .. **incurvatus**

6. Mesonotum with an arrow-shaped mark with head shaped similar to Fig. 27 .... **incognitus**

—. Mesonotum without a distinct median arrow-shaped mark .... **pingreensis**

Key to fifth instar larvae

1. Head width 1.75 mm. or more; middle femur 7.0 mm. or more 2

—. Head width 1.45 mm. or less; middle femur 5.5 mm. or less 3

2. Dorsum longitudinally striped .. **notabilis**

—. Dorsum not longitudinally striped .... **remigis**

3. Abdominal dorsum with a lateral series of pale spots to outside of medio-lateral series of fuscous markings 4

—. Abdominal dorsum without a lateral series of pale spots to outside of medio-lateral series of fuscous markings 6

4. Mesonotum antero-laterally with pale posterior pointing arrow-shaped marks; mesonotum with a median arrow-shaped mark, the head shaped as in Fig. 26 .... **buenoi**

—. Mesonotum anterio-laterally without pale arrow-shaped marks 5

5. Arrow-shaped mark in middle of mesonotum with head shaped as in Fig. 24 .... **comatus**

—. Arrow-shaped mark in middle of mesonotum with head shaped as in Fig. 25 .... **incurvatus**

6. Mesonotum with arrow-shaped mark in centre, and head with shape as in Fig. 27 . ... **incognitus**

—. Mesonotum without a distinct arrow-shaped mark in centre ...... **pingreensis**

Acknowledgements

This paper results from research supported by the National Research Council of Canada.

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Sprague, I. B., 1967. Nymphs of the genus **Gerris** (Heteroptera:Gerridae) in New England. Ann. ent. Soc. Amer. **60**:1038-1044.

THE BEETLES OF THE PACIFIC NORTHWEST

PartV: Rhipiceroidea, Sternoxi, Phytophaga, Rhyncophora, and Lamellicornia.

By Melville H. Hatch.

University of Washington Press, Seattle & London, 1971.

Pp. xiv and 662. $20.00 U.S.

In the final volume of this important series, Prof. emeritus M. H. Hatch has paid signal honor to three deceased British Columbia coleopterists and former members of this society. In the frontispiece are four portraits: the late E. C. Van Dyke, of San Francisco; Mrs. Marianne E. Parker Clarke (1880-1962) (formerly Mrs. Hippesley), of Terrace; Ralph Hopping (1868-1941), of Vernon; and George A. Hardy (1888-1966), of Victoria. The society acknowledges this graceful gesture from an old and valued friend and member.

Dr. Hatch's collaborators were: Mr. Merton C. Lane on nearly all the Elateridae; Mr. H. P. Lanchester on the Cardiophorinae in the same family; Dr. W. F. Barr on Buprestidae; Dr. L. G. Gentner on part of the Alticinae; Dr. B. D. Valentine on the Anthribidae; Mr. S. M. Hogue on the Trirhabda; and Dr. S. L. Wood on part of the Scolytoidea. Others have helped with smaller groups, and are acknowledged in footnotes.

The book was received too late for review by a competent taxonomic coleopterist. But since the 1300 spp. covered include most of the important economic plant feeding beetles in agriculture and forestry, it is possible for an ordinary working entomologist to make a fair appraisal of the book as a working tool. A very considerable number of pests is found in the Chrysomelidae, Curculionidae, Elateridae, and Scarabaeidae; in the Scolytidae, Buprestidae, and Cerambycidae. Like the earlier volumes, this one can be used as a reference as well as a key.

On the minus side are a few small irritants. Some are unavoidable, such as the unjustified right hand margins; others are avoidable, such as the spelling mistakes, e. g. M. G. Lane (p. 3), accomulated (p. 3), Hanford for Handford (pp. 195, 220), Vibernum for Viburnum (p. 257) the alter flea beetle on *Alnus* (p. 217), or the waterlilly leaf beetle (p. 201). There is also some lack of uniformity, such as J. Ec. Ent., Jr. Ec. Ent., and Jour. Econ. Ent.; or Oregon White oak (p. 437) and Oregon white oak (p. 439); Can. Dept. Sci. Serv. (p. 221), and so on.

The original figures and reproductions by permission from recent works, are clear and elegant. Where the figures are reproduced from older works by, e.g. Essig, Blatchley, or Chittenden, they are less successful, adequate perhaps but not elegant.

On the plus side the book has some features that strike me as excellent:

A 17-page index of several hundred authors of species in the Coleoptera. Abbreviations and full names are given, with dates and a line or two of biography and affiliations.

An index of Generic and Subgeneric names with a cross-index of trivial names.

Where they are applicable, common names are given in parentheses with the trivial names in the keys. Very many of these are not in the Ent. Soc. Amer. list, but are not the less valuable for that.

Associations with plant hosts are mentioned wherever possible. In fact, with some labor, a valuable index to the beetle fauna of plants in the region, could be made from these references. Where hosts are named in full, normal italics are used but not where genera only are mentioned.

This province is realistically divided into four regions, the boundaries of which are carefully defined (p. 4). These are not the same as those in Parts I and II.

A useful addition for the five volumes would be a list of addresses from which maps could be obtained, sufficiently detailed to locate most of the small towns and villages named.

A copy of Part V of this series is in the Society's library.

H. R. MacCarthy

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THE INFLUENCE OF TRAP DESIGN ON THE RESPONSE OF CODLING MOTH (LEPIDOPTERA: OLETHREUTIDAE) AND FRUITTREE LEAFROLLER (LEPIDOPTERA: TORTRICIDAE) TO SYNTHETIC SEX ATTRACTANTS[1]

HAROLD F. MADSEN AND JERRY M. VAKENTI[2]

Research Station, Agriculture Canada
Summerland, British Columbia

ABSTRACT

Trap design influenced the attraction of male codling moths, **Laspeyresia pomonella** (L.), and male fruittree leafrollers, **Archips argyrospilus** (Walker), to synthetic sex pheromones. White or blue Sectar 1 traps captured significantly more male codling moths than Pherotrap 1, U.C. Pherotrap or Sectar 2 traps when all traps were baited with Codlemone, a synthetic sex attractant of the codling moth. Cylindrical carton and Pherotrap 1-C traps were intermediate in effectiveness.

Pherotrap 1-C and cylindrical carton traps captured significantly more male fruittree leafrollers than Sectar I traps when the traps were baited with Fruitamone, a synthetic sex attractant of the fruittree leafroller.

The results indicate that trap design is an important factor when conducting tests on the response of codling moths or fruittree leafrollers to sex attractants.

INTRODUCTION

A number of papers on the use of virgin females or synthetic sex attractants to lure male Lepidoptera to traps have been published during the past 5 years. In these papers, more attention has been given to the lure than to the trap design. Sharma *et al.* (1971) showed that the attraction of male cabbage loopers, *Trichoplusia ni* (Hub), to a synthetic sex lure was influenced by the type of trap containing the lure. Trap design is probably an important consideration when field tests are conducted on male response to sex attractants of other Lepidoptera. This paper reports the influence of trap design on the response of male codling moths, *Laspeyresia pomonella* (L.) and male fruittree leafrollers, *Archips argyrospilus* (Walker) to synthetic sex attractants.

MATERIALS AND METHODS

The codling moth experiments were conducted in a mature heavily infested 1 hectare Red Delicious apple orchard at the Research Station, Summerland, B.C. The trees were 6.1 x 6.1 m apart and the block contained 228 trees. Seven trap types, each with 5 replicates, were hung in the trees in a randomized design. There was approximately 1 trap per 6 trees and each trap was suspended 1.6 m above ground on an outside limb. Each trap was baited with a rubber cap stopper (1 x 2 cm) impregnated with 1.0 mg of Codlemone (Zoecon Corporation, Palo Alto, California) a synthetic sex attractant of the codling moth. The caps were renewed every 4 weeks.

The trap designs were as follows: A cylindrical cardboard carton with a replaceable liner similar to that described by Proverbs *et al.* (1966). Pherotrap 1 (Zoecon Corporation) an open wing trap similar to the trap designed and illustrated by Howell (1972). Pherotrap 1-C (Zoecon Corporation) had a cardboard cover to protect the exposed surface. Sectar 1, white or blue, (3M Corporation, St. Paul, Minnesota) was a rectangular trap, 9 x 15 cm which was suspended by one corner so the opening was diamond-shaped. The ends of the trap were folded up when in use. The two colors were used because there was evidence that color influenced the attraction of certain Lepidoptera to traps containing a synthetic sex attractant (Hendricks *et al.* 1972). Sectar 2 was similar to the Sectar 1 trap, but larger (13 x 22 cm). U.C. Pherotrap (Zoecon Corporation) was an aluminum trap described and illustrated by Batiste and Joos (1972).

Stikem (Michael and Pelton, Emeryville, California) was used to coat the catching surface of each trap. The traps were routinely cleaned and replaced every 6 weeks or oftener if the sticky surface was contaminated by debris or wing scales from moth accumulation. The traps were examined weekly and male codling moths were removed and recorded.

Fruittree leafroller experiments were conducted in a 0.8 hectare mature Red Delicious apple orchard at the Research Substation, Kelowna, B.C. Visual examination

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[1]Contribution No. 366, Research Station, Summerland.

[2]Present address: Department of Biological Sciences, Simon Fraser University, Burnaby, B.C.

TABLE 1. Numbers of male codling moths captured in 5 traps per design baited with Codlemone.

Summerland, B.C., 1972

Trap Design	May			June				July				August				Sept.	Totals[1]
	15	22	29	5	12	19	26	10	17	24	31	7	14	21	28	4	
Sectar 1 (white)	44	25	36	65	30	26	10	18	23	116	59	78	106	30	57	50	773 a
Sectar 1 (blue)	38	20	25	52	25	22	16	4	34	133	59	62	111	23	53	49	736 a
Cylindrical carton	17	1	19	58	21	38	16	9	19	42	47	56	55	49	60	43	550 ab
Pherotrap 1-C	21	4	22	48	32	20	5	9	13	29	47	44	45	22	45	31	437 ab
Sectar 2	16	4	8	46	19	7	4	7	9	29	21	27	97	19	15	18	345 b
Pherotrap 1	22	6	1	23	12	9	2	16	12	43	38	25	39	23	33	32	335 b
U.C. Pherotrap	25	8	23	36	12	9	4	5	18	41	14	17	16	8	11	49	286 b

[1]Totals followed by the same letter are not statistically different. One tail t-test $P < 0.05$.

in May showed that the trees were heavily infested by fruittree leafrollers. The trees were 9.1 x 9.1 m apart and the block contained 126 trees. Three trap designs were evaluated, the cylindrical cardboard carton, Pherotrap 1-C and Sectar 1 white. Each trap design was replicated 5 times in a randomized design. There was approximately 1 trap per 8 trees and each trap was suspended 1.6 m above ground on an outside limb. The traps were baited with Fruitamone (Zoecon Corporation), a fruittree leafroller synthetic sex attractant. The lure consisted of plastic caps, 1.3 x 1.8 cm, filled with 25 mg of the sex attractant. The caps were not replaced during the experiment. Traps were examined weekly and leafrollers were removed and recorded.

RESULTS AND DISCUSSION

The white or blue Sectar 1 trap captured significantly more moths than Sectar 2, Pherotrap 1 or the U.C. Pherotrap (Table 1). Cylindrical carton and Pherotrap 1-C traps were intermediate in effectiveness.

An important consideration when deciding what trap design to use is trap maintenance. The cylindrical carton trap was easy to handle because dirty traps required only a change of the liner. The Pherotraps collected a considerable amount of debris (fallen leaves, fruit etc.) and required more frequent cleaning. The covered Pherotrap was far easier to maintain that the open Pherotrap but became contaminated more quickly than the cylindrical carton. Sectar 1 traps, because of their small size, were difficult to handle when moths were removed and recorded. When moth captures were high, the traps soon filled with wing scales and had to be replaced. Both Pherotraps and cylindrical cartons were re-used after cleaning, but it was necessary to replace the Sectar 1 traps with new traps 3 to 4 times during the season. Sectar 2 traps and the U.C. Pherotraps were relatively free from contamination and required only routine maintenance.

TABLE 2. Numbers of male fruittree leafrollers captured in 5 traps per design baited with Fruitamone. Kelowna, B.C., 1972.

Trap Design	June 12-22	June 22-29	June 29-July 6	July 6-13	Totals[1]
Cylindrical carton	19	93	195	31	338 a
Pherotrap 1-C	20	96	177	21	314 a
Sectar 1 (white)	7	14	91	0	112 b

[1]Totals followed by the same letter are not statistically different. One tail t-test, $P < 0.05$.

The choice of which trap design to use with a codling moth sex attractant is difficult to determine. If maximum capture is desired, the Sectar 1 trap would be the design of choice. If maintenance is also considered, the cylindrical carton would probably be the best trap design for field use.

Although Sectar 1 traps were among the most efficient traps for male codling moths, they captured significantly fewer male fruittree leafrollers than either the Pherotrap 1-C or the cylindrical carton (Table 2). For field studies on fruittree leafroller response to synthetic attractants, the cylindrical carton or Pherotrap 1-C would be the preferred trap design.

The results of the study indicate that attraction of male codling moths and fruittree leafrollers to synthetic sex attractants is influenced by trap type, and the response is different for the 2 species. Trap design may be as important as the synthetic attractant when studies are made on the response of other species of Lepidoptera to these lures.

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THE OCCURRENCE AND CONTROL OF THE BRUCE SPANWORM IN THE OKANAGAN VALLEY, 1972

R. D. MCMULLEN[1]

Research Station, Agriculture Canada
Summerland, British Columbia

ABSTRACT

A minor outbreak of the Bruce spanworm, **Operophtera bruceata** (Hulst), occurred in fruit orchards of the Okanagan Valley in 1972. The heaviest infestations were limited to orchards where prebloom sprays for the fruittree leafroller, **Archips argyrospilus** (Walker), were neglected for two or more seasons. Prebloom applications of azinphosmethyl, diazinon or endosulfan at tight cluster bud to pink bud stage on apple gave good control. Apple, pear, cherry, apricot and plum were attacked.

INTRODUCTION

The Bruce spanworm, *Operophtera bruceata* (Hulst), occurs in the southern parts of Canada from Newfoundland to British Columbia and across the northern U.S.A. Brown (1962) described the developmental stages, life history, and mode of dispersal and listed a wide range of host plants amongst spp. of: *Populus, Acer, Salix, Betula, Alnus, Prunus, Malus, Rosa, Ribes, Lonicera,* and *Amelanchier alnifolia* Nutt.

In British Columbia, Treherne (1921) stated that the larvae may cause surface injury to young apple fruitlets but indicated that it was less important than other species of lepidopterous larvae that regularly injure apple fruits. Eastham and Ruhmann (1932) noted that the Bruce spanworm had become a troublesome pest in apple orchards and that, in cases of heavy infestations, trees were kept defoliated until the end of May when larval development is completed. Twinn (1934, 1935, 1936) reported unusually heavy infestations in various parts of the Okanagan Valley. Control recommendations for the Bruce spanworm were a regular feature on the annual fruit tree pest spray calendars for British Columbia fruit growing districts from 1928 to 1943. Later, control recommendations were dropped from the spray calendars, and Neilson (1957) stated that the Bruce spanworm had not been a serious pest for the past 20 years. Downing *et al.* (1956) listed the Bruce spanworm as a sporadic pest of apple. None of the above articles mentioned infestations of fruit species other than apple.

During the past decade research has resulted in significant reductions in the amounts of pesticides required for control of major pest species, particularly on apple (Arrand and Downing, 1970), and in the future novel approaches to pest control, such as the sterile male release technique for codling moth control (Proverbs, 1971), may result in even further reductions. Concern has been expressed (Madsen, 1969) about possible increases in abundance of minor or secondary pests that in the past generally have been suppressed by control measures for major pests. Therefore, the opportunity to observe a minor outbreak of the Bruce spanworm in 1972 was of particular interest. In addition it

[1]Contribution No. 367, Research Station, Summerland.

was felt possible that the outbreak could be an indication that the Bruce spanworm had developed resistance to the organophosphorous insecticides currently recommended for control of early season major pests such as the fruittree leafroller, *Archips argyrospilus* (Walker). Control experiments were conducted to test whether a significant degree of resistance to azinphosmethyl or diazinon had evolved, and to provide information for control recommendations.

GENERAL OBSERVATIONS

The first indication of a Bruce spanworm outbreak was noted in a large cherry orchard at Naramata in the second week of April. Small, newly hatched larvae were noted burrowing into cherry buds. At the time cherry buds were about ready to break and apples were in the green tip stage. In one 2.0 ha block of cherries the infestation was particularly severe, with up to 50% of the buds damaged. In adjoining blocks of cherries and apples the infestation was much lighter, ranging from 1 to 2% buds attacked. Four other sites with high infestation levels, 10 to 60% buds damaged, were found. These comprised 4.5 ha of apples on the east bench in Penticton, 1.2 ha of apples in Summerland, 2.0 ha of mixed apple, pear, apricot, cherry and plum, south of Oliver and 4.1 ha of apples and cherries at Cawston. Otherwise, the Bruce spanworm was distributed widely in orchards throughout the Okanagan region, but at low levels of infestation with only 1% or less buds injured. No Bruce spanworm was found on peach. In orchards moderately to severely infested, it was determined that early season control treatments for leaf-feeding lepidoptera had not been applied for 2 or more years.

The damage caused by 1st and 2nd instar larvae is mainly reduction of bloom. Feeding by 1st instar larvae when they burrow into unopened buds results in destruction of embryonic blossom tissue. Later, when the buds have opened and immature blossoms are exposed, the 2nd instar and to a lesser extent early 3rd instar larvae prefer to feed on the immature flowers. During this period they still exhibit a strong tendency toward a mining habit. Most of the feeding occurs within the protection of the tightly closed sepals and petals or within clusters of flowers. The damage caused by 3rd and 4th instar larvae is primarily defoliation. These feed openly on leaves or within the shelter of leaves that have been loosely webbed together.

Two of the severely infested orchards, at Oliver and Summerland, were not sprayed for control of the Bruce spanworm until the pink bud stage of apple. At Oliver, approximately 0.8 ha of apples and pears were 75 to 90% defoliated by this stage and in the remainder of the orchard (1.2 ha of mixed fruits) 10 to 50% were defoliated. At Summerland, 1.2 ha of apples were 25 to 30% defoliated. Within 3 weeks after treatment the general appearance of the trees was normal due to growth of new foliage. In both orchards, even though there was extensive damage to flower buds, thinning of apple and pear fruitlets was required and the trees bore a normal crop. No fruit injury was found. This was probably due to the application of control treatments prior to fruit set.

CONTROL EXPERIMENTS

At the tight cluster bud stage the treatments listed in Table 1 were applied to 0.12 ha plots in an orchard consisting of alternate rows of Red Delicious and Spartan apples on semi-dwarfing rootstocks, planted 6.1 x 4.6 m. Each treatment was replicated twice. The sprays were applied with a low-volume, air-blast type sprayer set to deliver 673.8 liter per ha. Effect of the treatments was assessed 6 days after the sprays were applied by randomly collecting 25 spurs with flower bud clusters from each plot. These were examined for live and dead larvae, and also for feeding injury where no larvae were present. The latter instance was considered to indicate larval mortality. Per cent mortality in the treatments was corrected for natural mortality in the control by Abbotts' formula. The results shown in Table 1 indicate that all treatments gave good to excellent control of 2nd and 3rd instar larvae.

In another orchard of mature McIntosh apple trees planted 7.6 x 7.6 m the following treatments were applied in the same manner as above to single 0.30 ha plots at the pink bud stage: azinphosmethyl 50% W.P. at 2.80 and 1.40 kg per ha and diazinon 50% W.P. at 4.48 and 2.24 kg per ha. No nontreated control plot was used. At the time of treatment most of the larvae were 3rd and 4th instars. Pre- and post-treatment samples were taken by the limb-jarring method (Lord, 1949) using a 46 x 46 cm beating tray. Fifty samples taken at random throughout the 4 plots before treatment indicated a fairly even distribution of larvae. The numbers knocked down per sample ranged from 0 to 12 with a mean of 4.4 ± 1.4 s.d. Thirty samples from each plot taken 48 hours after treatment indicated all treatments gave 100% control.

DISCUSSION

This investigation suggests that the Bruce

Table 1. Mortality of the Bruce spanworm on apple treated with azinphosmethyl, diazinon or endosulfan at the tight cluster bud stage.

Insecticide	Kilograms applied per hectare	Per cent mortality[1, 2]
Azinphosmethyl 25% W.P.	2.80	100.0
" "	1.40	90.5
Diazinon 50% W.P.	4.48	100.0
" "	2.24	91.6
Endosulfan 50% W.P.	3.36	100.0
" "	1.68	100.0
Control	-	30.4

[1]Corrected for per cent mortality in control using Abbotts' formula.
[2]Average of 2 replicates.

spanworm might become more than an occasional pest if recommendations for reduced pesticide treatments or non-chemical control techniques are developed and adopted for the fruittree leafroller, which is the main early season lepidopterous pest of most orchard fruit species. The chemical control experiments show that the Bruce spanworm is readily controlled by prebloom treatments with azinphosmethyl or diazinon which are currently recommended for control of the fruittree leafroller. There is no evidence that the Bruce spanworm has developed resistance to the currently recommended organophosphate insecticides. The reason for the mild outbreak in 1972 of Bruce spanworm is most likely neglect of early season pest control.

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OCCURRENCE OF AND ATTEMPTS TO ERADICATE GRAPE PHYLLOXERA (HOMOPTERA: PHYLLOXERIDAE) IN BRITISH COLUMBIA[1]

C. V. G. MORGAN[2], P. J. PROCTER[3], AND J. VIELVOYE[3]

ABSTRACT

The chronological occurrence, survey methods, and eradication programs of the grape phylloxera, **Phylloxera vitifoliae** (Fitch), in British Columbia are described.

The insect was first found in the Okanagan Valley in 1961. Though an eradication program at that time was apparently successful, the insect reappeared in 1971. It is now well established in the area. The pest was accidentally introduced on imported vines.

The grape phylloxera, *Phylloxera vitifoliae* (Fitch), was first found in British Columbia in the Okanagan Valley in September, 1961. In that month a grape grower on the West Bench of the Penticton area reported leaf galls on vines that had been planted in the spring of 1961. The insects causing the galls were tentatively identified by Morgan and later confirmed by A. B. Stevenson, Research Station, Agriculture Canada, Vineland Station, Ontario.

Following the discovery, C. L. Neilson, J. Smith and J. C. Arrand of the British Columbia Department of Agriculture, conducted a survey and an eradication program in the autumn and spring of 1961-62. They found that the grape phylloxera had originated in a shipment from Ontario of 3000 vines of Seibel-10878. These vines had been planted in 6 places totalling over 4 acres; 5 of the plantings were on the West Bench in the Penticton area and 1 at Kaleden. Leaf galls were found at Kaleden and in only 1 of the plantings in Penticton. A total of about 12 vines were infested.

Since the areas of infestation were relatively small, eradication appeared feasible. In November, 1961, all the vines in the plantings at Penticton and Kaleden were removed from the soil, dipped in a solution of nicotine and oil, and heeled in for the winter. In April, 1962, the soils in the vineyards at Penticton were thoroughly worked with a rotary tiller; fumigated with a chisel-type, tractor-drawn fumigator that applied 240 to 300 lb of ethylene dibromide per acre; sprayed with ronnel emulsion at 4 lb active ingredient per acre; and then sprinkled with water. The vineyard at Kaleden was similarly treated, but because of the rocky soil and the steep terrain the ethylene dibromide and ronnel were applied by hand equipment. In May, the soils were rotary tilled again and the vines were replanted. At Penticton a slight odor of ethylene dibromide was still present during the planting operation. At Kaleden the planting holes had such a strong odor of ethylene dibromide that they were left open for up to 6 days before the vines were replanted. Approximately 23% of the replanted vines died. The phytotoxicity was caused mainly by the dip treatment, especially the oil. The high concentrations of ethylene dibromide which were still in the soil when the fines were replanted at Kaleden may have increased the injury. No phylloxera was ever reported again in these vineyards.

During the winter of 1961-62, Ontario nurserymen were advised to dip rooted cuttings destined for British Columbia. Either this treatment was not effective or it was not thoroughly done because when a survey was made in the summer of 1962 of vines imported that spring, Arrand found leaf galls on 1 vine in each of the following areas: 2 vineyards at Westbank (Seibel-5279), 1 vineyard at Summerland (Seibel-5279), 1 vineyard at Naramata (variety unknown), and 1 vineyard at Cawston (Seibel-10878). There were no root galls on the vines. The infested vines were removed and burned and the soil was fumigated and sprayed.

It is of interest to note here that between 1952 and 1961, 65 shipments containing 64,100 vines were imported into British Columbia from the United States. Eight of these shipments were infested with the grape phylloxera and were fumigated. Unfortunately, inspection or dipping of vine nursery stock from Ontario was not required until 1962 and fumigation not until 1967. The number of vines imported into British Columbia from Ontario between 1952 and 1961 is not known.

[1]Contribution No. 369, Research Station, Agriculture Canada, Summerland, B.C.

[2]Entomologist, Research Station, Summerland, B.C.

[3]Regional Entomologist and Grape & Nursery Specialist respectively, British Columbia Department of Agriculture, Kelowna, B.C.

However, it is known that in 1960, about 10,000 2-year-old rootstocks of Seibel-10878 were imported from Ontario and planted in virgin soil by about 25 growers from Westbank south to the International Boundary. Arrand surveyed all these plantings in the autumn of 1961, but did not find any other infestations of leaf galls other than those mentioned above.

With the eradication of the above-mentioned infestations and implementation of plant inspection regulations for all vines entering British Columbia, no other infestations were sought or reported for 9 years. However, an ominous report was made Sept. 27, 1971 — a grower discovered galled leaves in a vineyard of Foch grapes at Westbank. The insects in the galls were identifed by Arrand and Morgan as the grape phylloxera and confirmed by Stevenson. This 3-acre vineyard planted in 1967 was extensively infested. An adjoining 3-acre block planted in 1970 had 2 infested vines. A survey for leaf galls was launched tsh CCCooollIumbia and Canada Departments of Agriculture to determine the extent of the infestation in all major vineyards which had imported leaf-susceptible varieties since 1962. About 805 acres were examined and 2 new infestations were discovered. One was in another vineyard at Westbank; again there were only 2 infested vines in 5 acres of Foch grapes planted in 1968. The other was at Oliver where 1.5 acres were infested in a 3-acre block of Seibel-10878 planted in 1965. Though only about 70% of the vines in the heavily infested vineyards had leaf galls, nearly all were infested on the roots. An interplant, Seibel-9110, in the Oliver vineyard also had insects on the roots but no leaf galls. No insects were found on the roots of the vines with leaf galls in the lightly infested vineyards. Most of the above vines had been bought in Ontario.

A number of quarantine measures were implemented in an effort to confine the infestations such as fumigating the harvested grapes, spraying the vines after harvest, washing equipment before moving it to non-infested vineyards, and having pickers wear coveralls when working in infested areas.

Leaf galls are not always a realiable index of the presence of the grape phylloxera because the insect lives only on the roots of many *labrusca*-type grapes. A root survey in the outbreak of 1961-62 probably would have revealed a more extensive infestation than was indicated by leaf galls. Recognizing this weakness, a root survey was conducted in November and December, 1971, in vineyards of the Okanagan and Similkameen valleys. Due to the shortage of help and impending freeze-up, growers were instructed in how to sample their own vineyards. Provincial personnel then microscopically searched roots with swellings for the presence of the grape phylloxera. The number of samples examined represented about 2000 acres of grapes. Insects were found on the roots in 65 acres in 9 vineyards: 1 in Vernon, 6 in Kelowna, 1 in Westbank, and 1 in Oliver. The Westbank and Oliver infestations had already been revealed by the presence of leaf galls. The varieties and the number of acres affected by root infestations were: Bath, 2; Campbell Early, 8; Concord, 9; Diamond, 11; Foch, 3; Patricia, 3; Romulus, 4; Sheridan, 8; and Seibel-10878, 17. Most of the vines had been imported from Ontario; a few were from New York. Some of the vines had been planted in the 1920's and 1930's. How they became infested is not known, but it is more than likely they were already infested when they were imported. Phylloxera had been intercepted as early as 1927 on vines imported from New York.

Numerous samples of roots from other vineyards had elongated swellings and necrotic areas but no phylloxera was present to confirm that the damage was caused by this insect. Stevenson diagnosed these as "very probable" phylloxera damage. Unfortunately, samples with this type of damage were not recorded. They did suggest, however, that the grape phylloxera was probably more widespread than the 9 vineyards.

Hopes of eradicating the grape phylloxera from British Columbia were abandoned. The extent of the infestations indicated that such a program would be impractical and uneconomical.

No surveys were conducted in 1972 and no new infestations were reported. However, cursory inspections revealed that root galls were plentiful, but there were practically no leaf galls in the infested vineyards from Kelowna south. At Vernon, where only root galls were seen in 1971, a heavy infestation of leaf galls developed on several acres of Foch grapes.

The information in this note was gleaned mostly from correspondence and unpublished reports of the British Columbia and Canada Departments of Agriculture and from the Canadian Insect Pest Review (compiled by C. Graham MacNay and published by the Canada Department of Agriculture, Ottawa, Ontario) for 1961 (vol. 39, pages 209, 229, 285, and 309) and 1962 (vol. 40, pages 173 and 199).

AN EVALUATION OF TRAPS FOR THE WESTERN CHERRY FRUIT FLY (DIPTERA: TEPHRITIDAE)[1]

F. L. BANHAM
Research Station, Agriculture Canada
Summerland, British Columbia

ABSTRACT

Four traps and six lures were tested for attractiveness to adult western cherry fruit flies, **Rhagoletis indifferens** Curran, in cherry plantings in the Okanagan Valley of British Columbia. Staley Protein Insecticide Bait #7, a combination of corn protein hydrolysate and corn steep liquor, mixed into tanglefoot (Stikem Special) on double-faced, yellow, plywood boards attracted about twice as many flies as similar traps baited with corn hydrolysate and three times as many as single-faced, nonbaited boards. Nevertheless, nonbaited, single-faced, yellow boards were moderately attractive and the easiest to prepare, install and maintain. Thus they seem the most practical for large-scale trapping of cherry fruit flies. Traps caught male and female flies soon after emergence from pupation in a ratio of about 1:1. Most female flies lacked ovarial development and none had fully developed ova.

INTRODUCTION

Yellow sticky board traps similar to those described by Kaloostian and Yeomans (1944) and Wilde (1962) have been used since 1966, to determine the occurrence and emergence dates of the black cherry fruit fly, *Rhagoletis fausta* (Osten Sacken), and since 1968, of the western cherry fruit fly, *R. indifferens* Curran, in the Okanagan and Similkameen valleys of British Columbia. Madsen (1970) reported that in the Okanagan Valley, single-faced, yellow boards baited with ammonium carbonate caught the most *R. indifferens* but nonbaited, yellow boards were equivalent in attractiveness to glycine-lye bait pans. In contrast, Peters and Jack (1965) and Peters (1966) reported that in the Kootenay Valley, glycine-lye bait pans were more effective than nonbaited, yellow boards and those baited with ammonium carbonate or other attractants. At both locations the most effective traps were more complex to build and more difficult to install and maintain than the nonbaited, yellow boards.

The continuing spread of *R. indifferens* in the Okanagan and Similkameen valleys has resulted in an annual requirement for 5000 to 7000 simple, effective traps to sample this species in over 3000 acres of cherries. Growers need to determine if flies are present and the optimum time for control, and inspectors of the Plant Protection Division, Agriculture Canada, need traps to establish quarantine areas. In 1970, four traps and six lures were evaluated to determine the most suitable type for large-scale surveys of *Rhagoletis* species in cherry plantings.

[1]Contribution No. 364, Research Station, Agriculture Canada, Summerland, British Columbia.

MATERIALS AND METHODS

The traps used were as follows (Table 1.): 6.4 mm plywood boards 14 x 29 cm painted vivid yellow (Munsell Key 2.5Y 8/12 (Nickerson, 1957)) on one face and coated with Stikem Special (polymerized butene, methylpropene, isobutene and butane, 97% ; inert ingredients, 3% ; Michel and Pelton Co., 5743 Landregan Street, Emeryville, California, 94608, U.S.A.); double-faced yellow boards of the same dimensions, coated with Stikem on both sides having a wide-mouth half-pint jar suspended beneath containing 170 ml of Staley Protein Insecticide Bait #7 (acid hydrolysate of corn protein and corn steep liquor in a 60:40 mixture. A. E. Staley Manufacturing Co., Decatur, Illinois, 62525, U.S.A.); double-faced yellow boards sprayed on each face with 2.5 ml of Staley Bait which was mixed into the Stikem; double-faced yellow boards sprayed on each face with 2.5 ml of corn acid hydrolysate (Nutritional Biochemicals Corporation, Cleveland, Ohio, 44128, U.S.A.) which was mixed into the Stikem; double-faced yellow boards dusted on each face with 1 g of casein enzymatic hydrolysate (Nutritional Biochemicals Corporation) which was mixed into the Stikem; double-faced yellow boards dusted on each face with 1 g of soy enzymatic hydrolysate (Nutritional Biochemicals Corporation) which was mixed into the Stikem; 2-quart frozen food cartons with 20 g of ammonium carbonate (Frick, Simkover and Telford, 1954 and Blanc, 1969), fitted with replaceable, Stikem-coated liners (Proverbs, Newton and Logan, 1966); and glycine-lye bait pans (Barnes and Madsen, 1963) containing 227 ml of bait mixture. The total catching surface area of the

single- and double-faced yellow sticky board traps was equalized by using 12 of the former and 6 of the latter.

The attractiveness of the traps and lures to cherry fruit flies was determined in an abandoned, 1-acre, mixed block of 15-year-old Lambert, Sam and Van sweet cherries at Okanagan Mission, B.C. Two types of trap were hung 1.2 to 2.4 m above the ground on opposite sides of each of 27 randomly selected trees, so that there was no contact with the foliage. Cartons with ammonium carbonate were suspended in a nearby horizontal position with the open end tipped downward to prevent accumulation of rain and irrigation water (Blanc, 1969). The traps were installed June 6 and 8 and inspected at 3- to 4-day intervals until June 23, when the trial was terminated. Water was added at 3- to 4-day intervals to maintain the volume of the glycine-lye and Staley bait lures. The Staley bait was replaced and the ammonium carbonate cartons recharged, weekly.

Rhagoletis species were identified by wing patterns as illustrated by Bush (1966) and by dorsal abdominal markings. Most flies caught on the single- and double-faced boards and in the glycine-lye bait pots were identified in the field during inspections. When masses of insects, including fruit flies, were collected in the bait pans, they were removed by straining the solution through a 20-mesh wire screen and then stored in 70% ethanol for later examination. The sex of the flies was determined in the laboratory. At the end of the experiment, 50 female *R. indifferens* caught on three types of trap were removed and cleaned in petroleum solvent. Each was dissected and the ovaries were examined for the presence and development of eggs to determine their physiological age.

RESULTS

Double-faced, yellow boards with Staley bait mixed into the Stikem were significantly more attractive to *R. indifferens* than the other trap and lure combinations. They caught 1.9 times as many flies as similar traps with corn protein hydrolysate in the Stikem and for an equivalent surface area, three times as many flies as nonbaited, single-faced, yellow boards. The nonbaited traps were about as effective as double-faced, yellow boards with corn protein hydrolysate in the Stikem, double-faced boards with pots of Staley bait, glycine-lye bait pans and cartons with ammonium carbonate. Double-faced, yellow boards dusted with casein hydrolysate or soy hydrolysate did not catch any *R. indifferens* or insects of other orders in numbers comparable to those collected by the other traps.

Two *Rhagoletis* species other than *R.*

Table 1. Average numbers of adult R. indifferens caught by traps, Okanagan Mission, B.C., June 6 to 23, 1970

Trap	No. Traps	No. of Flies
Double-faced y.s.b.[1] + Staley bait	6	13.5
Double-faced y.s.b. + corn hydrolysate	6	7.0
Single-faced y.s.b.	12	4.5[2]
Bait pan + glycine-lye	6	3.3
Double-faced y.s.b. with pot + Staley bait	6	2.5
2 qt. carton + ammonium carbonate	6	1.2
Double-faced y.s.b. + casein hydrolysate powder	6	0.0
Double-faced y.s.b. + soy hydrolysate powder	6	0.0
L.S.D. for averages at 5% level		4.3

[1]Yellow sticky boards.

[2]Corrected number for an equivalent surface area of double-faced yellow boards.

indifferens were trapped. These were a few *R. ribicola* Doane and *R. berberis* Curran, taken on nonbaited, single-faced boards, on double-faced, yellow boards with Staley bait in the Stikem or attached bait pots and in cartons with ammonium carbonate. No *R. fausta* were trapped.

Corn protein hydrolysate or Staley bait mixed into the Stikem darkened the adhesive and made trapped flies difficult to identify in the field. *Rhagoletis* species were easily confused with other Diptera having fuscous wing markings such as *Palloptera* species (Pallopteridae) and *Suillia* species (Heleomyzidae). Casein and soy hydrolysates mixed into the Stikem made the adhesive cloudy and reduced the intensity of the vivid yellow background on the boards.

Catches of flies from the effective traps and lures did not differ significantly in sex ratio. The totals averaged 47.4% male and 52.6% female. Most dissected females collected from nonbaited, single-faced, yellow boards, double-faced, yellow boards with pots of Staley bait or pans of glycine-lye bait showed a lack of ovary development. Two of 50 females had fully developed ovaries but no fully developed eggs.

DISCUSSION

The results of this study show that the attractiveness of yellow boards to adult *R. indifferens* can be greatly increased by mixing small amounts of Staley bait into the adhesive; but large amounts of this lure were not attractive and may have confused or repelled the flies. Thus, double-faced, yellow boards with 5 ml of Staley bait mixed into the Stikem caught 5.4 times more flies than similar boards with 170 ml of Staley bait in a pot suspended below. Much of the attractiveness of small amounts of this lure appeared to be due to the corn steep liquor fraction. Traps with Stikem and Staley bait containing 40% corn steep liquor caught 1.9 times more flies than those with Stikem and corn hydrolysate.

Madsen (1970) reported nonbaited, single-faced, yellow boards to be as effective as glycine-lye bait pans for catching adult *R. indifferens*. These results confirm this and indicate that the former is a simple, moderately effective alternative to more complex types. Nonbaited, single-faced, yellow boards are durable and easy to prepare, install and inspect. Until a clarified or near-transparent formulation of corn hydrolysate and corn steep liquor is available that is equal to Staley bait, or until other more attractive lures and traps are discovered, then nonbaited, single-faced, yellow boards remain the most practical trap for large-scale surveys of cherry plantings.

Cartons baited with ammonium carbonate and hung in a nearly horizontal position were as effective as nonbaited, single-faced, yellow boards. Frick *et al.* reported good results with inverted, 1-quart cartons baited with the same lure. They also found that inverted, 1-pint cartons were inferior to inverted, 1-quart cartons. In the Okanagan Valley, 2-quart cartons were used. These were twice the size of those recommended by Frick *et al.* and presumably because of their larger size would have emitted more ammonia attractant. Horizontal positioning may have made this trap too directional and thereby reduced the numbers of flies caught. The attractiveness of yellow boards suggests that increased catches might result from painting the cartons vivid yellow.

Failure to trap any adult *R. indifferens* or insects of other orders in significant numbers suggests that powdered baits mixed into the Stikem on double-faced, yellow boards altered the surface of the adhesive so that flies did not become entangled. This contradicts that reported by Howitt and Connor (1965) who dusted 3 g of various powdered protein hydrolysates over each face of a 206 sq. cm trap coated with Stikem. In the Okanagan Valley, 1 g of hydrolysate was applied to each face of a 406 sq. cm board and mixed into the Stikem.

The presence of nearly equal numbers of male and female flies in or on the traps suggests that both sexes emerge from pupation in the soil at about the same time and are soon attracted to the cultivated cherry host.

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PHYTODECTA ARCTICA MANN. (COLEOPTERA: CHRYSOMELIDAE) INCORRECTLY DETERMINED FROM GARIBALDI PARK, B.C.

W. Lazorko

The holarctic species *Phytodecta (Gonioctena) arctica* Mann. was reported from Garibaldi Park by Hardy (1927). Hardy had collected several insects there in the previous year between July 24 and August 12, on the glacier and on leaves of willow (*Salix commutata denudata*). The identification of the specimens was questioned by Hatch (1971), who thought they might be *P. occidentalis* Brown.

Through the kindness of Prof. G. G. E. Scudder of UBC and the cooperation of Drs. B. D. Ainscough and R. H. Carcasson of the Provincial Museum in Victoria, I have been able to examine six specimens labelled "Garibaldi, B.C." and collected between July 24 and August 7, 1926 on the glacier at 6600 feet. One specimen also bears the label "Phytodecta arctica Mann." written in ink. There is no doubt that these specimens are some of those collected by Hardy and reported as *P. arctica.*

My study shows that the specimens are not *P. arctica*, but *Chrysomela aeneicollis* Schaeff. The latter species has been reported from Garibaldi Mt. by Brown (1956) and there are many specimens from this locality off willow, in the Spencer Entomological Museum at the University of British Columbia. *P. arctica* should thus be removed from the list of Coleoptera from Garibaldi Mt., and perhaps also from the list of Coleoptera of B.C.

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OCCURRENCE OF THE STRAWBERRY TORTRIX, *ACLERIS COMARIANA* (ZELLER), A NEW PEST IN BRITISH COLUMBIA (LEPIDOPTERA:TORTRICIDAE)

W. T. CRAM

On June 29, 1972, several strawberry plantings in Richmond, British Columbia, were observed to be severely infested by a new leafroller later identified as the strawberry tortrix, *Acleris comariana* (Zell.). This field infestation is the first occurrence of this Northern European pest in Canada. By the time the pest was discovered first instar larvae had matured and had seriously reduced the yield by damaging blossom parts which produced malformed fruit or no fruit at all. Heavy feeding on developing leaves greatly reduced the area of the mature leaves which were extremely ragged with large holes. In one 10-acre field the crop was picked only once before the planting was turned under.

Since only the second generation stages were observed in 1972, a later paper will deal with the complete life history in British Columbia. In England, *A. comariana* is considered an important pest of strawberry (Vernon, 1971) dating back to 1883 (Petherbridge, 1920). Observations at Richmond agree closely with details of the life history reported from England (Petherbridge, 1920 and Turner, 1968).

In early instar larvae the head is black but in later instars the head is pale brown. Both types of larvae, which might easily be mistaken for different species, were found together throughout May and June and again from July until mid-September. Both larvae and pupae were parasitized by several local parasitic hymenopterans. The adult moths occurred from late June to early August and again from early September until mid-November. They have a distinctive dark brown patch in the costal area of the forewings. The general wing coloration is variable; some eight polymorphic forms are known in England (Fryer, 1928), most of which have been collected at Richmond. The second generation moths lay the over-wintering eggs at the base of the leaf petioles. The pest can thus readily be spread by transporting runner plants containing over-wintering eggs. The moths are not strong fliers.

A survey revealed that this new pest occurred in 1972 only in Richmond and not further east in the Fraser Valley where most of the strawberries in the province are grown. It has a relatively wide host range in Northern Europe where it occurs on strawberry, apple, azalea, rose and especially potentilla. It occurs also in Northern Japan on apple and strawberry. The method of entry of this pest into Canada is not known.

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Dr. A. Mutuura of the Entomology Research Institute, Canada Department of Agriculture, Ottawa, identified the moth and larvae. Drs. E. G. Munroe and T. N. Freeman also examined the specimens and provided additional information.

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ECOLOGY OF ANTHOCORID (HEMIPT.: ANTHOCORIDAE) PREDATORS OF THE PEAR PSYLLA (HOMOPT.: PSYLLIDAE) IN THE OKANAGAN VALLEY, BRITISH COLUMBIA

G. J. FIELDS[1] AND B. P. BEIRNE[2]

ABSTRACT

The supposition is not valid that the disappearance of the native **Anthocoris melanocerus** from pear orchards late in the summer is because of competitive displacement by the introduced **A. nemoralis.** It is because **A. melanocerus** migrates to where prey are most abundant whereas **A. nemoralis** remains on pear. **A. melanocerus** is concentrated on willows in the spring, moves to pear when **Psylla pyricola** becomes abundant, and moves to cottonwood when aphids on it become abundant and the numbers of **P. pyricola** on pear have become low.

INTRODUCTION

Three species of predacious anthocorids attack the eggs and nymphs of *Psylla pyricola* Forster, the pear psylla, in the Summerland area of the Okanagan Valley, British Columbia (McMullen and Jong, 1967). Two, *Anthocoris melanocerus* Reuter and *A. antevolens* White, are natives. The third, *A. nemoralis* (F.), had been introduced into that district from Switzerland in 1963 in a biological control attempt against *P. pyricola* (McMullen, 1971). It became established and subsequently became the most common of the three species in some orchards. *A. melanocerus* also is common but *A. antevolens* is relatively scarce.

Local orchard entomologists noticed that *A. melanocerus* disappears late in the summer from orchards where *A. nemoralis* is common, whereas *A. nemoralis* remains there until it moves to hibernation sites. Possible causes of this disappearance were investigated in 1969, notably to see whether or not it was because of competitive displacement (as defined by DeBach and Sundby, 1963, and DeBach, 1966) of *melanocerus* by *nemoralis* as was suggested by McMullen (1971). The existence of competitive displacement would tend to support the view of Turnbull and Chant (1961) that species being considered for introduction for biological control purposes should be screened to ensure that they will not interact detrimentally with others that attack the same target species.

Populations of anthocorids and of psyllids were sampled regularly in four pear orchards that contained *A. nemoralis* and in two that had not yet been colonized by it, in hibernation sites, and on 31 species of plants growing in and near the orchards. *A. antevolens* was found only relatively rarely in these surveys, perhaps because there was heavy mortality of the hibernating population during the winter of 1968-69 which was exceptionally cold (-20 to -30 F). Consequently meaningful figures were obtained only for *A. nemoralis* and *A. melanocerus*. Six species of plants other than pear had substantial populations of *Anthocoris* spp.: willows (*Salix* spp.), cottonwood (*Populus trichocarpa*), ash (*Fraxinus* spp.), birches (*Betula* spp.), nettle (*Urtica lyallii*), and thistle (*Cirsium edulii*).

Psylla pyricola populations on pear were measured by counting the numbers of eggs and nymphs on 50 leaves picked at random from five trees in each orchard on each sampling date. Anthocorid populations were measured by sampling regularly, for adults and nymphs, ten pear trees in each orchard, and willows and cottonwoods nearby, with a beating-tray technique.

[1]Present address: Mid-Columbia Experiment Station, Hood River, Oregon.

[2]Contribution from: Pestology Centre, Department of Biological Sciences, Simon Fraser University, Burnaby 2, B.C.

RESULTS AND CONCLUSIONS

The population surveys on pear showed that:

(a) *P. pyricola* reached a peak in numbers in June when there was an average of 5 to 10 individuals per leaf. It then decreased to about one per leaf by the beginning of August and remained at or near that level until the end of the season.

(b) *A. nemoralis* appeared first late in April, increased to a peak late in July and early in August, and then declined to the end of October.

(c) *A. melanocerus* appeared first early in June, reached a peak about mid-July, and had disappeared by early August.

The early disappearance of *A. melanocerus* was not because it went into hibernation early,

because surveys by means of artificial hibernation sites consisting of bands on tree trunks showed that all three species of *Anthocoris* sought hibernation sites at about the same time in any one locality.

(d) *A. melanocerus* disappeared from pear orchards early in August whether or not they were inhabited by *A. nemoralis*. Moreover, chi-square analyses of the numbers of *A. melanocerus* found on pear on each sampling date showed that the populations were statistically equal in orchards with and without *A. nemoralis*.

Thus, the indications were that *A. nemoralis* had no direct or significant influence in causing the disappearance of *A. melanocerus*, and therefore that there was no competitive displacement of the native species by the introduced *A. nemoralis*.

The surveys for *Anthocoris* spp. on willow and cottonwood showed that:

(a) *A. nemoralis* occurred on willows during the second half of May, but otherwise this species was apparently virtually specific to pear.

(b) *A. melanocerus* occurred on willows from late in April until early in June and, in large initial numbers, on cottonwood from late in July until at least mid-September (the last survey date).

Two species of psyllids, a *Trioza* sp. and *Psylla* sp. (not *pyricola*), that were common on willows in the spring and an unidentified aphid that was abundant on cottonwood in the late summer were the main prey of *A. melanocerus* on those plants.

Where *A. melanocerus* occurred commonly at different times during the season evidently depended on where suitable prey insects were most abundant. It seems reasonable to conclude that its disappearance from pear during the second half of July was because food supplies in the form of *P. pyricola* had become scarce on pear or, in the form of aphids, abundant on cottonwood, or both, and that this caused *A. melanocerus* to migrate from pear to cottonwood.

Scanty data obtained on *A. antevolens* indicates that it may have similar habits to *A. melanocerus*.

It is possible that *A. nemoralis* could have had some indirect influence in causing *A. melanocerus* to leave pear late in July by contributing to lowering the population of *P. pyricola* to the level that may have induced *A. melanocerus* to move to more abundant prey on other plants.

The existence of willows near pear orchards evidently contributes to the natural control of *P. pyricola* because they have large populations of prey psyllids in the spring on which populations of *A. melanocerus* build up and then move to the pear trees. Whether or not the willows influence in the same manner the populations of *A. nemoralis* on pear is not known. If they do, the influence probably is minor because larger populations of *A. nemoralis* developed in the spring on pear than on willows.

Acknowledgements

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OBSERVATIONS ON *ARCTIA CAJA AMERICANA* HAIR (LEPIDOPTERA: ARCTIIDAE) ON TANSY RAGWORT, *SENECIO JACOBAEA* L.

Bernard J. R. Philogene
Department of Plant Science
University of British Columbia, Vancouver 8, B.C.

ABSTRACT

This is the first record of **Arctia caja americana** Hair on tansy ragwort, in British Columbia. The development of the insect on the weed, its polyphagous habits and its potential as an experimental animal are reported and discussed.

INTRODUCTION

Tansy ragwort, *Senecio jacobaea* L., is a well established noxious week in pastures of the lower Fraser Valley, and on Vancouver Island, British Columbia (Wilkinson, 1965). Up to now only four insects had been observed feeding on the weed in those areas: an Arctiid moth, *Phragmatobia fuliginosa* L.; an aphid, *Aphis lugentis* Williams; a leaf-mining fly, *Phytomyza atricornis* Meigen; and the introduced cinnabar moth, *Hypocrita jacobaeae* L. The plant is known to harbour many more insect species in other parts of North America, particularly in the western United States (Frick, 1964, 1972; Frick and Hawkes, 1970), but no mention was made of the garden tiger moth, *Arctia caja americana* Hair., in these reports. Observations made on this insect in the course of the spring and summer of 1972 are reported here.

Large woolly-bear caterpillars were collected on a north-facing field at Clearbrook in the Fraser Valley during the second week of June. Twenty-nine of the 36 larvae collected were actively feeding on tansy ragwort. The remaining larvae were collected on plantain, thistle, and equisetum but there was no indication that they were eating these weeds. The larvae were reared in the lab on tansy ragwort and reached the pupal stage in eight days. Two larvae devoured three fully-grown tansy ragwort leaves every 24 hr. at room temperature. Silken cocoons were spun on the walls of the cage within which the larvae moulted to brown chrysalids. Adult emergence occurred after three weeks. No mating was observed in the daytime. Oviposition started after five days. The eggs were laid on the leaf under-surface and on the main stem of tansy ragwort potted plants but mostly on the wooden frame of the cage. Some females attempted to lay on the screening. The eggs were in batches varying from 19 to 287. All the eggs that were not laid on the wooden frame (60.3% of the total) failed to hatch. Adults showed signs of reduced activity after ten days and died 13 to 16 days later. First instar larvae hatched within eight days, and immediately made their way to the tansy ragwort if the eggs had not already been placed on it. Development to the fifth instar proceeded according to the schedule given in the text table below:

ARCTIA CAJA AMERICANA HAIR: Development at room temperature on tansy ragwort

Embryonic development	7-8	days
1st instar	5-6	"
2nd instar	5-6	"
3rd instar	5-6	"
4th instar	6-9	"
Cocoon spinning and molting	2	"
Pupa	20-21	"
Adults	13-16	"
Life cycle	63-72	"

The wooly-bear caterpillars then became sluggish and practically stopped feeding, entering what appeared to be a state of hibernation. According to Moreau (1964) who reared the insect on plantain, *Arctia* goes through seven instars and may have one complete, followed by one partial generation a year, in France. This does not seem to be the case here.

A Dipterous parasite emerged from pupae of the moth: *Carelia reclinata* A. & W. (Tachinidae, Diptera)[1]. Nine of the field collected individuals, i.e., 31 were thus parasitized, the number of parasites per individual varying from 1 to 16.

Larvae emerging from eggs in the lab were also reared on apple, cherry, pear, tomato, hybrid grape, radish and lettuce leaves. No development occurred on tomato and grape. Development appeared to proceed normally on

[1]Supported by University of B.C. Research Committee Grant No. 24-9552.

[1]Identified by D. M. Wood, Entomology Research Institute, C.D.A., Ottawa.

lettuce but after three days the larvae died. The other four types of leaves were acceptable to the wooly-bear caterpillars, but the moths which emerged from larvae fed on them were smaller than those whose larvae had developed on tansy ragwort. There were variations in colouration also.

Arctia caja americana is a polyphagous insect with a wide range of hosts. From this point of view, it is an ideal tool for plant insect relationship studies. The adult is also one of those warningly-coloured insects which store secondary plant substances (Rothschild, 1972). Our observations show that it is very easy to rear in the lab on tansy ragwort. The polyphagy of this insect makes it an unlikely biological control agent for *Senecio jacobae.* It would seem, on the contrary, that it should be watched carefully because, in spite of what we have observed, Moreau (1964) also reports it to be an active feeder in its early instars on *Vitis vinifera.* It does not seem, however, to be able successfully to complete its cycle on this economically important plant, at least in France. The presence of a Dipterous parasite indicates that it is partly under biological control in normal conditions. Further studies are being carried out on the feeding range and habits of this insect, and particularly on its use of secondary plant substances.

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NOTES ON DISPERSAL, LONGEVITY AND OVERWINTERING OF ADULT *PISSODES STROBI* (PECK) (COLEOPTERA: CURCULIONIDAE) ON VANCOUVER ISLAND

L. H. McMullen and S. F. Condrashoff[1]

ABSTRACT

Observations of dispersal, longevity and overwintering behavior are recorded. Some adult weevils lived up to 4 years, moved at least 1.2 km, and many overwintered in the upper parts of trees as well as in litter.

Pissodes strobi was formerly considered three species: *P. strobi* (Peck), the white pine weevil; *P. engelmannii* Hopk., the Engelmann spruce weevil; and *P. sitchensis* Hopk., the Sitka spruce weevil. The last two have been placed in synonymy (Smith and Sugden, 1969). However, the common names are retained here to designate the regional groups.

The Sitka spruce weevil destroys the leader of regeneration Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and is a pest in coastal Oregon, Washington and British Columbia (Wright, 1960; Silver, 1968). A knowledge of the adult behavior is important in developing approaches to control of the insect. This report presents information on the activity of marked weevils released in the fall and of weevils caged in various locations. It adds to the knowledge of the insect's dispersal, longevity and overwintering behavior.

DISPERSAL

Adult weevils, reared from infested leaders, were mared in groups of 25 to 50 by spraying with fluorescent paint[2]. This treatment did not appear to inferfere with the insect's activity and marked weevils were easily distinguished, although the red paint was difficult to detect in later years. In September 1968, approximately 10,000 adults, marked red, and, the following September, a similar number marked green were released in the San Juan Valley about 14 km inland from Port Renfrew. The weevils were dropped among the branches near the top of 3- to 4-m-tall Sitka spruce trees in a logged-over area with western hemlock (*Tsuga heterophylla* (Raf.) Sar.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Sitka spruce regeneration. During May and June, 1969 through 1972, adult weevils, handpicked for other purposes from Sitka spruce leaders there and in other areas of regeneration up to 3.6 km away, were examined.

Marked weevils were readily seen the following March to May on the release and surrounding trees. As the season progressed, their proportion decreased to a small percentage of those found in late June. During 1969, weevils released in 1968 were recovered only up to 180 m from the release site. However, in subsequent years, weevils released in both 1968 and 1969 were found up to 1.2 km away (Table I).

The white pine weevil can move several hundred metres (Goodwin *et al*, 1957), but most individuals do not move that far (Harman and Kulman, 1967a; Dirks, 1964). Our findings indicate that the Sitka spruce weevil can move readily (at lease 1.2 km from September to May), but observations in a newly infested plantation suggest that it generally remains close to its origin. Of 700 spruce trees in the plantation, 3 were infested in 1967; 21 in 1968, and 65 in 1969. Of the infested trees, 62% in 1968 and 77% in 1969 were within 18 m of the previous year's infested trees, whereas only 21 and 45 , respectively, of all trees were within this area.

LONGEVITY

Although no weevils released in 1968 were found after 1970, four released in 1969 were found in 1972 (Table I), when they were 3 years old. In addition, fourteen weevils (8 females and 6 males), released in 1968 and recovered in spring 1970, were maintained subsequently in 6.3 x 7.1 cm (16 x 18 in) mesh fibreglass sleeve cages on parts of trees which appeared suitable for their seasonal behavior; i.e., on terminals during spring and early summer, on shaded laterals until October and near the base of the stem of 2.5-m tall trees until April or early May. One weevil was still living in the fall of 1972. Establishment of brood in the terminals in each of the 3 years (Table II) shows that surviving adults were capable of reproduction for at least 4 years.

[1]Pacific Forest Research Centre, Victoria, B.C.

[2]Fluorescent fast dry spray paint 501-H110 (red), British America Paint Co., Ltd.: Kem Hi-Gloss Safety green spray paint 649-FR26.

Table I. Numbers of released weevils recovered in collections at different distances from the release center

Year	Dates of collections	Distance from release center (km)											
		0			0.4			1.2			3.6		
		68	69	UN[1/]	68	69	UN	68	69	UN	68	69	UN
1970	May 4-15	18	187[2/]	154	-	-	-[3/]	3	2	366	-	-	-
	May 16-31	-	-	-	2	2	46	0	0	166	-	-	-
	June 1-15	2	12	93	3	4	64	0	1	331	0	0	173
	June 16-30	2	1	59	-	-	-	-	-	-	0	0	157
1971	May 10-17	0	0	8	-	-	-	0	3	415	0	0	91
	May 26-27	0	3	10	0	2	247	0	1	127	-	-	-
	June 15-16	0	0	23	0	0	189	0	2	43	0	0	99
1972	May 8	-	-	-	-	-	-	0	1	14	-	-	-
	May 23-24	0	3	23	0	0	66	0	0	62	0	0	60

1/ 68, 69, UN = 1968-, 1969-released and unmarked wild weevils, respectively.

2/ observed but not collected

3/ - = no collections

	Date		Adults		Number of progeny		
	Caged	Examined	number[1]	age (years)	larvae	pupae	adults
1970	April 3	Aug. 5	3	2	4	6	0
	April 3	Aug. 5	5	2	30	86	8
	June 19	Aug. 5	6	2	0[2]	0	0
1971	May 3	July 2	5	3	13	1	0
	June 21	Aug. 8	5[3]	3	31	10	0
1972	April 29	July 2	2	4	16	4	0

1/ At least 1 male in each cage except 1972 which is uncertain.

2/ Adults oviposited and larvae started mining but appeared to be pitched out.

3/ Same adults as those caged May 3.

Table 2. Brood produced by Sitka spruce weevils in successive years.

This insect lives at least 2 years on eastern white pine (Harman and Kulman, 1967b) and on Sitka spruce (Carlson, 1971). Our tests suggest that adults may survive up to 4 years. Such longevity, if common, would reduce the effectiveness of control measures based on removal of infested leaders prior to emergence of the young adults. The failure of such procedures in the east has been attributed to reinfestation of an area by weevils moving in from outside (Dirks, 1964). However, our experience indicates that even where damage is localized and such reinfestation of treated areas might not be expected, old adults could cause damage for several years.

OVERWINTERING

In late September 1970, approximately 1000 marked[1] weevils were released on each of three 2.5-m-tall Sitka spruce trees in the San Juan Valley, approximately 2.0 (Mainline), 7.2 (Mosquito) and 12.1 (Lens) km, respectively, east of Port San Juan beach. Six-inch lengths of spurce branches to which the adults were clinging were placed next to the stem on branches of the third to fifth whorl. The branches and stem of each tree were carefully examined each month from November to April and the location of observed weevils were recorded. In addition, a sample of duff (15 x 61 cm) from the base of each tree was examined in January and the remaining duff within 61 cm of the base was examined in April.

[1]Glowz fast drying fluorescent spray paint lemon yellow, New York Bronze Powder Co., Inc.

Date	Site		
	Mainline	Mosquito	Lens
Nov. 12	207	407	90
Dec. 11	124	152	69
Jan. 19	87	146	54
Feb. 12	66	91	39
Mar. 12	77	83	42
Apr. 26	37	116	19

Table 3. Number of marked weevils released in late September found on release trees during winter of 1970-71.

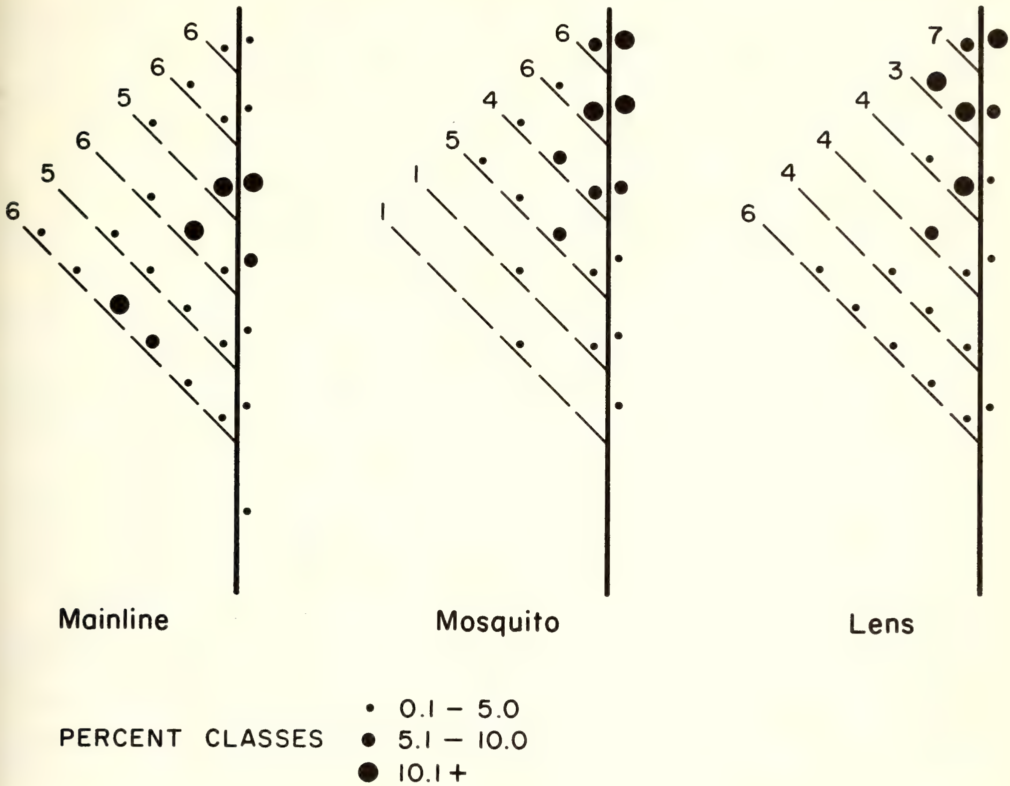

Fig. 1. Distribution of weevils on three trees as percent of total weevils on tree, November to April, 1970-71. Numbers indicate branches in each whorl.

Fewer weevils were found on the trees (Table III) than were released. In spite of careful search, some weevils were apparently missed, since sometimes more were found in subsequent examinations. The insects were on the bark among the needles, usually on the underside of the main laterals, and among needles or around the base of laterals on the stem. Most were on the laterals, although the number per internode was higher on the stem than on the laterals. The distribution did not change much during the winter. Data from all six observations were combined in Figure I. The Mainline site tree was next to a main logging road, and the resulting disturbance may have caused many weevils to move lower on the tree. At the other two sites, the majority remained near the stem and in the upper portion of the tree.

Eighteen live marked weevils were found in the duff in January (1 at Lens, 9 at Mosquito and 8 at Mainline) and an additional three were found in duff at each of the Lens and Mosquito sites in April.

In the east, the white pine weevil overwinters within the duff and litter (Belyea and Sullivan, 1956), but neither Silver (1968) nor Carlson (1971) found naturally occurring Sitka spruce weevils overwintering in the duff or on trees. However, Silver released weevils on trees and found some in the duff around the base and on the lower 23 cm (9 in) of the bole; Carolson found released weevils distributed throughout the tree. Gara *et al.* (1971) reported 100% mortality of adults caged in duff but good survival in cages on terminals and laterals. Our data indicate that weevils overwinter in trees but that some may winter in the duff.

Gara *et al.* (1971) assumed that weevils feed actively during winter whenever temperatures are high enough for insect movement. The apparent discrepancies relating to overwintering sites, therefore, may

be due to differing winter conditions. Carolson's work was done in moderate conditions in southwestern Washington, whereas Silver's was in the Nitinat Valley about 36 km from the west coast of Vancouver Island. Our observations were probably in an intermediate winter climate.

Resume

L'auteur rapporte ses observations sur la propagation, la longevite et la facon d'hiverner de ces insectes. Quelques Characons adultes vecurent jusqu'a 4 ans, se deplacerent sur au moins 1.2 km et plusieurs hivernerent dans les parties superieures des arbres ou sur la litiere.

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ECOLOGICAL NOTES ON ORTHOPTERA *(S. STR.)* IN BRITISH COLUMBIA

V. R. VICKERY AND B. NAGY*

ABSTRACT

Collections and observations were made of the grasshoppers of the semi-arid Okanagan Valley of British Columbia, during August and September, 1969. The habitats, frequency and local distribution of 37 species are discussed, based on 40 collecting sites.

HABITATS

During August and September, 1969, the second author collected and observed Orthoptera in British Columbia, near Penticton and Summerland in the semi-arid Okanagan Valley near the south end of Okanagan Lake. Adjacent to the lake, on the hillsides and on the low plateau of silty loess of glacial origin, are many apple orchards grown under irrigation (Fig. 1), and beyond the irrigated areas (350-500 m) the vegetation is typical of xerophytic range land.

The different habitats (or biotopes), were sampled on 40 collection sites mostly by sweeping-net, but also by capturing single specimens. Based on these sites, some conclusions may be drawn as to the frequency of occurrence and on habitat distribution (Table 1). The numbers of collection sites in each habitat were not equal; 21 sites were in xerophytic, 17 in mesophytic and only 2 in hygrophytic areas.

This is the first account of the habitats of the grasshoppers of this area. More detailed information on each of the sites is on file at the Research Institute for Plant Protection, Budapest, Hungary and at the Lyman Entomological Museum and Research Laboratory, McGill University, Macdonald Campus, Ste. Anne de Bellevue, Quebec, Canada.

The specimens were identified by the first author. Some have been retained in the Lyman Entomological Museum, but about 70% have been deposited in the collection of the Research Institute for Plant Protection, Budapest. The species collected are listed below by sex and the habitats in which they were found.

The characteristics of the various biotopes in which the collections were made may be summarized as follows:

I. Xerophytic areas.

I-A, short-grassland; pasture with variable scattered bushy vegetation on silty loess of glacial origin; at somewhat greater altitude, a plateau with more sand and gravel (360 to 500 m). The vegetation consisted of discontinuous, short grasses, *Agropyron* and *Bromus* species, with bare spots among low bushes of Oregon grape, *Berberis aquifolium* Pursh, antelope brush, *Purshia tridentata* (Pursh) D.C. (at Okanagan Falls only), but with rabbit-brush, *Chrysothamnus nauseosus* (Pall.) Britt., and sagebrush, *Artemisia tridentata* Nutt., predominating; cactus, *Opuntia fragilis* (Nutt.) Haw., and *Centaurea* spp. (Compositae) were also significant; mostly eroded areas with disturbed surfaces and soil-slides with variable exposures; 3 collection sites.

I-B, disturbed weedy areas on sandy-gravelly soil at low elevations (360 to 500 m) in the vicinity of orchards and residential gardens, supposedly originated secondarily from the grassland biotope; vegetation sparse, mixed grasses and weeds, *Agropyron*, *Bromus*, asparagus-*Asparagus officinalis* L., *Kochia*, *Gyposophila*, sagebrush and *Rhus* species, etc.; scattered miscellaneous bushes and single pines *Pinus ponderosa* Laws., also occurred; 3 small collections.

I-C, ponderosa pine park-forest; dry slopes with short-grass pasture at middle elevations (500-800 m), in sparse pine forest; more or less sparse short grass, with significant numbers of scattered bushes of squaw currant - *Ribes cerum* Douglas, *Amelanchier* sp., rabbit-brush, sagebrush, cactus and *Centaurea* spp. also occurred; many places were disturbed, overgrazed, or in roads, etc.; 4 collection sites.

I-D, relatively undisturbed clearings in the lower montane coniferous forest (800 to 1400 m) joined with some denser ponderosa pine park-forest (650 to 800 m); clearings with dry, relatively homogeneous short grass, with some forbs (e.g., *Gaillardia* sp., Compositae) and some bushes, notably *Amelanchier* sp. and snowbrush -

*Dr. V. R. Vickery, Lyman Entomological Museum and Research Laboratory, Macdonald Campus of McGill University, Ste. Anne de Bellevue 800, P.Q., Canada: Dr. Barnabas Nagy, Novenyvedelmi Kutato Intezet, Research Institute for Plant Protection, Budapest II, Herman O. u. 15., Hungary.

Fig. 1. General view of south end of Okanagan Lake from the Summerland area.

Ceanothus sp., probably *velutinus* Douglas; denser forest at higher elevation (more than 800 m) with Douglas firs - *Pseudotsuga menziesii* (Mirib.) Franco and occasional patches of *Juniperus* spp.; in the smaller clearings, the sparse short-grass was interspersed with low clumps of snowbrush and *Vaccinium* spp.; generally rough terrain with eroded rocks and scattered boulders. Habitat type I-D represented an extensive and important area; 4 collection sites between 650 and 800 m and 7 between 800 and 1400 m.

II. Mesophytic areas.

II-A, the residential garden area of Summerland, near Powell Beach, along roads and bare ground at low altitude (360 m); generally sandy-gravelly soil deposited by Trout Creek; vegetation consisting of patches of willow and poplar, with occasional asparagus, *Berberis*, sweet clover - *Melilotus alba* Desr., and sagebrush; 4 collection sites.

II-B, as in II-A, in the residential garden areas, mainly near Powell Beach (360 m); vegetation a mosaic of more or less cultivated legumes, ornamental, vegetable and fodder crops, such as alfalfa (lucerne) - *Medicago sativa* L., sweet clover and *Lotus* sp. together with grasses; 7 collection sites.

II-C, large disturbed clearings in the ponderosa pine park-forest zone (500-800 m) and in the lower montane coniferous forest zone (800 to 1300 m); the mainly mesophytic character of this habitat was shown by the presence of small groves of poplar, *Symphoricarpos,* and moisture-requiring bushes; besides pine and fir, there occurred grasses - *Hordeum* sp., forbs such as spp. of *Potentilla, Melilotus, Mentha, Verbascum, Centaurea, Erigeron, Achillea* and *Solidago. Juniperus* spp., *Rosa* spp., *Ceanothus* and *Vaccinium* were the most prominent plants in these habitats at higher elevations; 3 collection sites (500 to 800 m) and 3 more at higher elevation (800-1300 m).

III. Hygrophytic areas.

Flat ground with depressions at low altitude; homogeneous dense grass with scattered sedges, *Carex* spp., goldenrod, *Solidago* spp., popular and willow trees and

bushes on moist soil; 2 restricted collection sites.

SPECIES AND BIOTOPES

Gryllacridoidea

Rhaphidiphoridae

Ceuthophilus sp., 1♂ and 1♀ juv., probably *agassizi* (Scudder), habitat I-C, Penticton (Niggertoe Mt.), found under a decayed tree trunk.

Grylloidea

Gryllidae

Gryllus sp., 2 young nymphs, probably *G. veletis* (Alexander & Thomas) also in habitat I-C, Penticton.

Allonemobius fasciatus (DeGeer), 4♂♂ and 2♀♀, habitats II-B and III, Summerland. Usually found only where moisture is available. It was located by continuous chirping.

Oecanthidae

Oecanthus sp., probably *O. argentinus* Saussure (antennae broken off) 1♂, 1♀, habitat II-A, Summerland (lake-shore); also detected in habitat II-C by stridulation.

Tettigonioidea

Tettigoniidae

Steiroxys trilineatus (Thomas), 2♂♂, 4♀♀, habitats I-C, I-D, Summerland but more numerous at Penticton (Niggertoe Mt., eastern and western clopes). Buckell (1922) reported it as *Steiroxys* sp. on open range land.

Phaneropteridae

Scudderia furcata furcata Brunner, 4♂♂, 2♀♀, habitats II-A and III, Summerland (near Powell Beach), on humid spots only. Populations of this species tended to be small and localized here, but specimens were often seen sitting on the tops of willow bushes, feeding and chirping.

Conocephalidae

Conocephalus fasciatus (DeGeer), 3♂♂, 2♀♀, habitat III, on sedge, Summerland. Remarks on the occurrence of *S. f. furcata* largely apply to this species also.

Tetrigoidea

Tetrigidae

Tetrix subulata (Linnaeus), 7♂♂, 1♀, 3 juv., habitat II-C, Summerland (Concle Mt., dried up pond), Penticton ("Naramata" Mt., 1300 m). It was localized in mesophytic depressions in areas otherwise xerophytic.

Tetrix ornata occidua Rehn and Grant, 1♂, habitat II-C, Penticton ("Naramata" Mt., 1300 m), in company with *T. subulata*.

Acridoidea

Acrididae

Melanoplinae

Melanoplus sanguinipes sanguinipes (Fabricius), 48♂♂, 34♀♀, in all xerophytic and mesophytic habitats, Summerland, Penticton, Naramata, and Okanagan Falls; the most common and widespread species of *Melanoplus* in British Columhia and across southern Canada.

Melanoplus femurrubrum femurrubrum (DeGeer), 25♂♂, 21♀♀, in all habitats except I-C, Summerland and Penticton. Usually found in vegetation which was somewhat lush, so that it was less common than *M. s. sanguinipes*, although the general distribution was about the same.

Melanoplus packardi Scudder, 1♀, found only in habitat I-B, Summerland, near Trout Creek, on a sandy slope, with some ponderosa pine, at 400 m. This species was reported from British Columbia by Brooks (1958) but not by Buckell (1922, 1924). Not common, it was usually confined to sandy or gravelly areas with xerophytic vegetation.

Melanoplus bivittatus (Say), 17♂♂, 11♀♀, in all habitats examined in mesophytic and hygrophytic areas, Summerland and Penticton, at lower and higher altitudes and in more lush vegetation than other *Melanoplus* species of the area. Common in the residential garden area, often seen climbing and sitting on garden vegetables and particularly on high forbs, such as sweet clover, at twilight, basking, as indicated by Riegert (1967).

Melanoplus alpinus Scudder, 2♂♂, 4♀♀, habitats I-D and II-C, Summerland (Concle, Acland, Niggertoe Mts.) and Penticton ("Naramata" Mt.). Buckell (1922) stated that this species was fairly common in dry Douglas fir forests in the Chilcotin area. Brooks (1958) reported it from montane parklands and grasslands, similar to the collection sites recorded here.

Melanoplus huroni Blatchley, 1♂, 10♀♀, habitats I-C, I-D and II-C, Summerland (Concle, Niggertoe, Acland Mts., Darke Creek). Primarily a forest species, occurring in disjunct populations.

Melanoplus infantilis Scudder, 4♂♂, 2♀♀, habitats I-C and I-D, Summerland, although Buckell (1922) reported it as very common on range land in the Chilcotin area.

Phoetaliotes nebrascensis (Thomas), 2♂♂, habitat I-A, Okanagan Falls, in pasture where antelope brush predominated.

Buckellacris nuda nuda (E. M. Walker),

1♂, 1♀, habitat II-C, Summerland (Darke Creek), on the south side of Acland Mountain in bushy mixed vegetation, mainly snowbrush and juniper, grown or remaining after deforestation.

Oedipodinae

Camnula pellucida (Scudder), 12♂♂, 11♀♀, habitats I-C, I-D, II-B and II-C, Summerland. It is surprising that this species was not found in all xerophytic and mesophytic areas.

Dissosteira carolina (Linnaeus), 9♂♂, 9♀♀, habitats I-A, I-B, I-C, II-A and II-B, Summerland and Penticton. Found only on bare spots, roads, and trails in disturbed cultivated places. The sunny roadsides in the garden areas of Summerland and Penticton were basking places for adults. It was common to see specimens killed by automobiles. *C. pellucida* and *D. carolina* are found from the Atlantic to the Pacific in Canada.

Arphia pseudonietana pseudonietana (Thomas), 14♂♂, 8♀♀, nearly all habitats of the xerophytic and mesophytic areas at Summerland and Penticton. Reported as common in the British Columbia dry belt by Buckell (1922).

Spharagemon equale (Say), 6♂♂, 8♀♀, habitats I-A, I-C, I-D, and II-B, Summerland (Niggertoe Mt., Darke Creek).

Cratypedes neglectus (Thomas), 4♂♂, 5♀♀, habitats I-C, I-D and II-C, Summerland (Niggertoe Mt., Concle Mt., Darke Creek). Although the habits were similar to those of the preceding species, they were found together at only one of seven sites.

Circotettix rabula rabula Rehn and Hebard, 6♂♂, 2♀♀, habitats I-D and II-C, Summerland (Niggertoe Mt., Acland Mt.) and Penticton ("Naramata" Mt.), on bare eroded, cleared areas or outcroppings of rock or gravel, mostly at higher elevations.

Trimerotropis pallidipennis pallidipennis (Burmeister), 3♂♂, 2♀♀, habitats I-B, I-C and II-B, Summerland (Concle Mt.) and in a disturbed weedy place at Penticton. This species usually occurs in small colonies on sandy soil in protected places with sparse vegetation.

Trimerotropis sparsa (Thomas), 4♂♂, 3♀♀, habitat I-A, Summerland. Not previously recorded in the literature from British Columbia. It apparently occurs infrequently and is confined to bare areas on eroded hillsides and silty loess plateaus. At the same site were found other grasshoppers, *Melanoplus s. sanguinipes*, *M. f. femurrubrum*, *Spharagemon equale*, *Amphitornus coloradus ornatus* and an undetermined *Trimerotropis* sp. (below).

Trimerotropis verruculatus suffusa Scudder, 31♂♂, 21♀♀, habitats I-C, I-D, II-B and II-C, Summerland and Penticton, at higher places in most xerophytic and mesophytic biotopes, often in company with *Circotettix r. rabula*. It occurs all over southern British Columbia, rather evenly distributed in light, open woodlands (Buckell, 1922).

Trimerotropis fontana (Thomas), 31♂♂, 30♀♀, habitats I-A, I-B, I-C, I-D, II-B and II-C, Summerland and Penticton; common and widespread.

Trimerotropis species, 2♂♂, habitat I-A, Summerland, on silty loess plateau at 420 m. This species was recorded by Buckell (1924) as *T. gracilis* (Thomas). Brooks (1958) reported it from British Columbia as *T. gracilis sordida* E. M. Walker, but the first author of this paper found that it was not this subspecies. Further work will establish the identity of the specimens from British Columbia. It was found in company with the species listed under *Tr. sparsa*, above.

Pardalophora apiculata (Harris), 4♂♂, 8♀♀, third instar nymphs, habitats I-D and II-C, Penticton ("Naramata" Mt., 1300 m) with *Chloealtis conspersa*, *Tetrix* and *Melanoplus* species; in another habitat it was found with *Melanoplus s. sanguinipes*, *Arphia p. pseudonietana*, *Trimerotropis suffusa* and *Tr. fontana*. Based on Pickford's statements (1953), these specimens may have been overwintering nymphs. They were collected on September 5 and were kept in a warm place, about 25-30 C., exposed to sunshine; two did moult to the adult form in October, but later all died during a long journey.

Gomphocerinae

Aulocara elliotti (Thomas), 2♀♀, habitats I-A, Summerland, dry pasture at 500 m, and II-C, Naramata, lakeshore with silt, sand and rocks in sparse vegetation. Brooks (1958) reported this species as very localized on dry, grassy hillsides in some areas of Saskatchewan and Manitoba and common on grasslands in northwestern Alberta. Buckell (1922) recorded *A. elliotti* as plentiful "on the open Bunchgrass flats in the Lower Okanagan Valley."

Ageneotettix deorum deorum (Scudder), 3♂♂, 7♀♀, habitats I-A and I-B, Summerland and Penticton. Previously recorded from British Columbia as *Ageneotettix occidentalis* Bruner. This was corrected in an unpublished list by Buckell (1937).

Amphitornus coloradus ornatus McNeill,

3♂ ♂, 7♀ ♀, habitats I-A and II-C, Summerland and Penticton. In this instance, the mesophytic habitat was a small, isolated area in terrain which was otherwise xerophytic. Buckell (1922) reported it as *A. nanus* R. & H., common in dry areas of southern British Columbia.

Chloealtis conspersa Harris, 3♂ ♂, 1♀, one locality in habitat II-C, Penticton ("Naramata" Mt., at 1300 m), with *Chloealtis abdominalis, Tetrix subulata, T. ornata occidua*, three *Melanoplus* spp. and oedipodine nymphs. Buckell (1922) reported *C. conspersa* as fairly common and evenly distributed in the interior of the province.

Chloealtis abdominalis (Thomas), 9♂ ♂, 6♀ ♀, habitats I-C, I-D and II-C, Summerland and Penticton. Reported by Buckell (1922) to occur in the same habitats as the preceding species but more numerous. The present collections confirm that it is more numerous but the two species did not often occur together. *C. conspersa* was found in the Okanagan Lake area at only one of the 8 sites where *C. abdominalis* was taken. The first author has found biotopic distribution similar to that reported here, at Salmon Arm, British Columbia.

Orphulella pelidna deserta Scudder, 2♂ ♂, 6♀ ♀, habitats II-B and II-C, Summerland, near Powell Beach and Concle Mt., in local pockets of heavier vegetation in moist soil.

Chorthippus curtipennis curtipennis (Harris), 5♂ ♂, 2♀ ♀, habitats I-D and II-C, Penticton ("Naramata" Mt., at 1000 m). Normally found only in mesophytic and hygrophytic habitats, it was surprising to find it in ponderosa pine park-wood with sparse vegetation; the reason might be some spotty green grass-patches and a nearby mesophytic habitat.

Notes on Dominance, Abundance and Distribution

About 60% of the species which occur in the xerophytic biotopes of southern British Columbia are represented in the collection. If a full range of habitats had occurred in the area, the number of species would undoubtedly have been greater. Most of the species collected were found in predictable habits.

Trimerotropis sparsa (Thomas) was not previously recorded in the literature from British Columbia and *Steiroxys trilineatus* (Thomas) was reported earlier without a specific name (Buckell, 1922).

Scudder (1862) included a few species of Orthoptera from western Canada and Caudell (1904) listed species from a single area of Alberta. Walker (1906; 1910) added more species but none of these papers contained ecological notes of any significance. Buckell (1921, 1922, 1924) and Treherne and Buckell (1924a, 1924b) provided brief notes on the ecology of some of the species of Orthoptera found in British Columbia. These are the only ecological records on this group in this area to date. Handford (1961) reported in greater detail on one species, *Camnula pellucida* (Scudder). In general, the records cited were from the range areas of the Chilcotin District, near Riske Creek, and from the Nicola Valley. Few species were listed from the geographical area covered here. However, the ecological notes do not vary significantly.

Unfortunately, the different collecting sites do not have the same importance in the various habitats, but an approximate impression is given by the numbers of specimens of the most numerous species: *Melanoplus s. sanguinipes, Trimerotropis fontana, Tr. verruculatus suffusa, M. f. femurrubrum* and *M. bivittatus*, which were the most numerous in the late summer of 1969. *Arphia p. pseudonietana* and *Camnula pellucida* were also numerous. *Camnula* would be expected to be as common and to occur in an equally wide range of biotopes, but it was found only in certain habitats near Summerland. *Tr. fontana* might be expected to occur less frequently than *Camnula*, but this was not the case. *Melanoplus f. femurrubrum* was, as expected, confined mainly to areas where moisture was more abundant than is necessary for *M. s. sanguinipes*. *M. bivittatus* is more restricted by availability of moisture than either of these species.

Because of the relatively late season, the abundance of the grasshoppers generally was estimated to average rather less than one specimen per sq. m; in only three collecting sites was the population estimated to be greater than this. At a collecting site in the xerophythic habitat I-A (sagebrush and short-grass pasture at 400 m elevation) the abundance was estimated as 1-2 specimens per sq. m; the most abundant species here were *Trimerotropis fontana, Arphia p. pseudonietana* and *Melanoplus s. sanguinipes*. In a mesophytic collecting site, the abundance was estimated as 2-3 specimens per sq m, which was the highest encountered. This was in habitat II-B, an artificially cleared meadow with a weedy alfalfa-field at 800 m elevation. The species found were *Trimerotropis fontana, Arphia p. pseudonietana, Melanoplus s. sanguinipes, M. bivittatus* and *Camnula pellucida*. On a third collecting site, in the mesophytic habitat II-C,

Biotope		Altitude**	No. Sites	No. Species
Xerophytic - I				
	A*	l	3	12
	B	l	3	8
	C	m	4	15
	D	m	4	12
	D	h	7	14
Mesophytic - II				
	A	l	4	7
	B	l	7	13
	C	m	3	11
	C	h	3	17
Hygrophytic - III		l	2	5

*Classification within biotopes as outlined in text.

**Altitudes: l = 360-500; m = 500-800; h = 800-1400m.

Total Species - 37; total specimens - 512.

Table 1. Numbers of species of Orthoptera collected at 40 sites in three habitats, Okanagan Lake area, British Columbia, August and September, 1969.

a disturbed clearing-pasture with scattered popular bushes and weeds at 950 m elevation, the abundance was estimated to be 1-2 specimens per sq m. The grasshopper population here consisted of *Melanoplus s. sanguinipes*, *M. f. femurrubrum*, *M. bivittatus*, *Arphia p. pseudonietana*, *Trimerotropis fontana* and *T. verruculatus suffusa*.

Table 1 presents summarized data on the distribution, and thus on the occurrence, of the species in the different habitats and indicates the frequency of occurrence, within the different habitats. Habitats I-D and II-C may be seen to be divided into two groups, middle (under 800 m) and higher (over 800 m) altitudes. Since the different habitats are not represented equally by collecting sites, the comparative value of species numbers in Table 1 is reduced somewhat.

There were only slight differences in species numbers between the three altitudinal biotic zones; 23, 21 and 20 species were found in the grassland (360 to 500 m), in the ponderosa pine park-forest zone (500 to 800 m) and, in the lower montane coniferous forest zone (800 to 1400 m) respectively. These differences in species numbers were less than 10% . However the vertical distance investigated was only a little more than 1000 m. In the Rocky Mountains of North Colorado (Alexander and Hilliard, 1969), the reduction in species number in similar habitats and for the same vertical distance was greater than 50% . The area in question is only about 1100 km to the south of Summerland, but it is much higher. Consequently, the degree of altitudinal difference is hardly comparable.

The middle ponderosa pine park-forest region contained a mixed group of species of Orthoptera consisting of some common elements in both the lower region: *Dissosteira*, *Spharagemon*, *Trimerotropis p. pallidpennis*, *Amphitornus* and *Orphulella;* and also in the upper regions: *Steiroxys*, *Tetrix subulata*, *Melanoplus huroni*, *M. alpinus*, *M. infantilis*, *Circotettix r. rabula* and *Chloealtis abdominalis;* but few of these species are confined to the region. Therefore, based solely on this one summer's investigation in the area, the ponderosa pine park-forest zone may be

considered as an intermediate ecotone between the short-grassland and the lower montane coniferous forest zone. Table 1 shows the general pattern of this distribution.

Several species were found to be confined to a particular biotope or to closely related habitats. Among these, habitat I-D, clearings with dry grasses, scattered bushes, mixed pine and fir forest with occasional patches of juniper, was preferred by 16 species; *Melanoplus infantilis* and *Steiroxys trilineatus* were collected almost entirely in this habitat. Habitat II-C proved the richest with 21 species; this habitat is related to type I-D, but is generally characterized by more humidity and disturbance and therefore more ecological factors than habitat I-D. *Tetrix subulata, T. ornata occidua, Buckellacris n. nuda, Chloealtis conspersa* and oedipodine nymphs (*Pardalophora apiculata*) were found in habitat II-C only. *Melanoplus huroni, M. alpinus, Circotettix r. rabula* were restricted to these two habitats, and *Trimerotropis verruculatus suffusa* and *Chloealtis abdominalis* were most often found here.

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EMERGENCE AND ORIENTATION BEHAVIOR OF BROOD *TRYPODENDRON LINEATUM* (COLEOPTERA: SCOLYTIDAE)[1]

J. H. BORDEN AND C. E. FOCKLER[2]
Pestology Centre, Department of Biological Sciences,
Simon Fraser University, Burnaby, British Columbia

ABSTRACT

Emergence of **Trypodendron lineatum** from caged naturally infested host logs occurred from June 2 to August 27, 1969. Approximately 30% of the parent beetles emerged before June 30, when the first major brood emergence took place. The sporadic brood emergence was apparently influenced by maturation, and markedly by environmental temperature. A daily emergence. A total of 6,539 beetles emerged, with a ♂ : ♀ sex ratio of .997. Emergent brood beetles were hygronegative and strongly photopositive, indicating that behavioral reversals in both humidity and photic responses must occur since the beetles select and occupy moist, dark overwintering sites.

INTRODUCTION

Brood *Trypodendron lineatum* emerge from their host in mid to late summer and fly to overwinter in the litter and duff of the forest floor, in rotting stumps or under the bark scales of standing trees (Kinghorn and Chapman 1959, Chapman 1960). Very little is known about the behavior of these beetles prior to their entring an overwintering site where they remain in a reproductive diapause (Fockler and Borden 1972) for the winter months. However, emergent beetles in the summer appear to be photo-positive (Dyer and Kinghorn 1961), even though they eventually orient to sites where light intensity is minimal. A knowledge of the behaviour of brood beetles may lead to their eventual manipulation and control.

This paper describes the emergence behavior and orientation to humidity and light of brood *T. lineatum* from coastal British Columbia.

EMERGENCE FROM HOST LOGS

Thirteen logs, .5 to .8 m long and 18 to 24 cm in diamter, were removed from naturally-infested Douglas fir slash near Brackendale, B.C. First attack was noted on May 1, 1969 and the heavily infested logs collected on May 23. They were transported to Simon Fraser University and placed in screened cages (approx. 1 m^3) in an outdoor enclosure with a translucent roof. Temperature and humidity were monitored with a portable hygrothermograph placed in one of the cages. Each day, insects emerging from the logs were collected intermittently until 9:00 p.m. Beetles were sexed on collection.

The enclosure of field-collected logs permitted a more precise observation of emergence (Fig. 1) than through interpretation of the numbers of beetles trapped in flight (Chapman and Dyer 1960; Rudinsky and Daterman 1964). A total of 6,539 beetles emerged (♂:♀ sex ratio .997), commencing on June 2. Observations ceased on August 27 following 2 weeks of consistently low emergence. Log dissections on June 4 to 12 disclosed that no brood had yet pupated indicating that the first emergence consisted entirely of parent adults. Since approximately 10 days are required for pupation (Prebble and Graham 1957), the June 30 emergence peak probably represents the first major brood emergence. Of the 1076 beetles collected before June 30, 199 were prematurely emerging callow adults. The remaining 877 beetles were presumably parents representing approximately 30% of the attacking population (there were 1531 attacks counted on the debarked logs following emergence). The June 30 emergence occurred 48 days after the initial attack, a period 21 days shorter than under field conditions in Europe (Hadorn 1933). At this time many galleries still contained eggs and early instar larvae. The peak emergence in the first 3 weeks of July was as much as one month earlier than noted for beetles in the field (Chapman and Dyer 1960; Rudinsky and Daterman 1964) but maturation was probably influenced by high cage temperatures.

Mortality was severe, possibly due to a fungus found growing profusely in many tunnels. Only 4.3 beetles emerged per gallery, far less than the minimum expected number of 10 emergent brood beetles (Hadhorn 1933). Thus, a conservative estimate of brood mortality would be at least 50%. A similar mortality rate of parent beetles would leave

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[2] Nee Slater

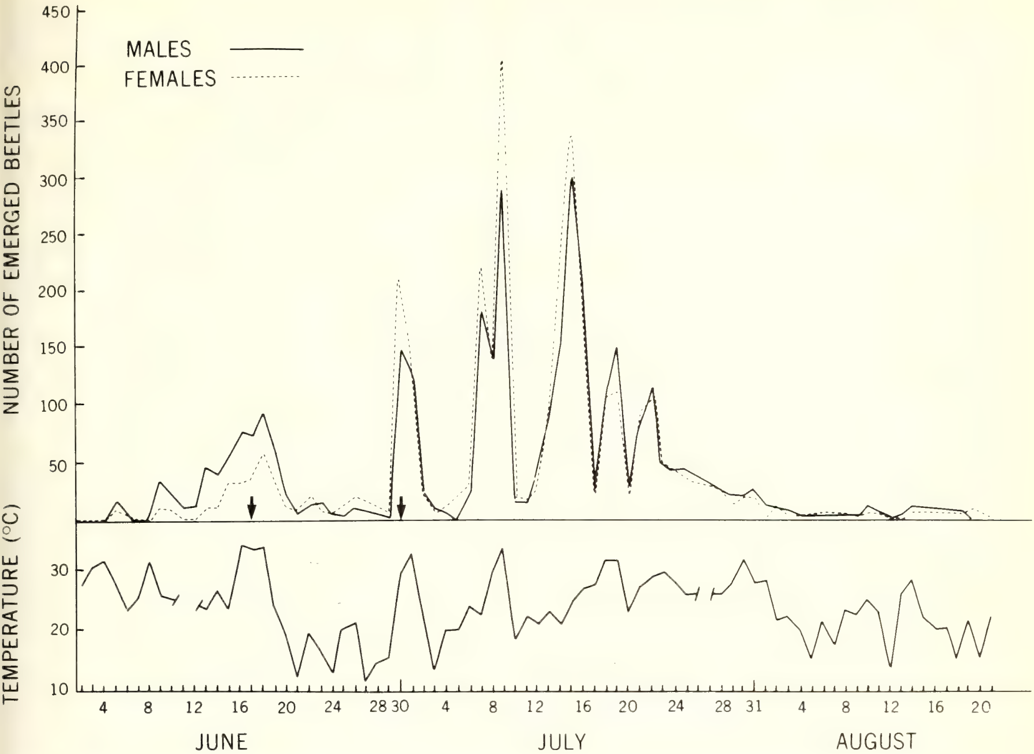

Fig. 1. Daily maximum temperature and emergence of **T. lineatum** parents and brood adults from naturally infested, caged logs. Arrows denote period of callow adult emergence.

approximately 36% of the original parents unaccounted for. Therefore, we assume that at least 80% of the 5,463 beetles which emerged after June 30 were brood beetles. Some of the higher female emergence after June 24 (Fig. 1) undoubtedly represents parent females.

The sporadic emergence during July appeared to reflect brood maturation trends and the occurrence of sufficiently high temperatures to stimulate emergence. Minimum temperatures were often similar. However, most emergence peaks coincided with high maximum temperatures (Fig. 1). From June 29 to July 25, emergence was analyzed in two groups: days when less than 100 beetles emerged, and days when more than 100 beetles emerged. For the former, the daily mean maximum temperature and emergence, respectively, were 24.1° C (range = 14.4 to 31.1° C) and 44.6 beetles, while for the latter, they were 31.3 C (range = 23.3 to 37.8° C) and 332 beetles. On 7 occasions, fewer than 100 beetles emerged on days when maximum temperature was higher than 24° C. However, on only one day did more than 100 beetles emerge when the maximum temperature did not reach 24° C. Therefore, we conclude that 24° C (75 F) is the critical ambient temperature to induce a mass emergence. Following cool periods a lack of mature beetles apparently delayed peak emergence. For example, only 50 beetles emerged on July 6 when the maximum temperature reached 26.7 C, but 350 beetles emerged on July 7 with a maximum temperature of 25.6° C.

ORIENTATION OF BROOD BEETLES TO HUMIDITY AND LIGHT

After June 30, beetles were collected for experimentation within 2 hours of emergence and held at approximately 4° C and 100% Relative Humidity (R.H.). The only flight possible was in the small emergence cage prior to collection.

Humidity preference at 20° C was examined in a 2-choice apparatus consisting of a cylindrical plastic vessel 10 cm in diameter and 11 cm deep, with a plastic lid. A screen mesh arena separated the upper and lower halves of the apparatus. A partition in the lower half extended to the screen mes, creating 2 chambers in which humidity was controlled by CaCl crystals (0%), concentrated aqueous solutions of MgCl (34%) and NaCl (77%),

and water (100%) (Janisch 1938). The upper half of the chamber was also divided by a partition in line with the lower but leaving an 8 mm space above the screen on which walking beetles could freely choose a desired atmosphere.

Prior to each test, the apparatus was allowed to equilibrate with 2 experimental solutions for ½ hour, and the beetles were conditioned to room temperature for 15 minutes. Two replicates of 20 beetles were run for each sex in light and dark conditions for 3 humidity alternatives: 0-34% , 0-77% and 0-100% . Controls were run in light conditions at 77-77% R.H. The apparatus was placed in the centre of a square, unmarked box and rotated 180 halfway through each experiment. The position of test beetles was noted at one-minute intervals for 30 minutes, and the mean response calculated. Counting beetles in dark tests necessitated brief exposure to a very dim light held directly above the chamber.

At alternatives of 0-77% and 0-100% for both sexes under both light and dark conditions, and at 0-34% for males in the dark, the drier atmosphere was clearly preferred (Table 1). All the above preferences were significantly different from the controls (t-test, $P < .01$). The reduced ability to discriminate between 0 and 34% R.H. suggests that humidity discrimination at this stage of the beetle's life need only differentiate between conditions of high and low moisture, the circumstances most likely to occur during emergence from host logs.

The photic orientation of emerging beetles was examined on July 16 at the University of British Columbia Research Forest, Maple Ridge, B.C. Twelve logs infested in early May were piled in the centre of a 2.1 m cage covered with white cloth which allowed diffuse, but relatively natural lighting. Light intensity readings were recorded every 30 minutes from 11:00 a.m. to 9:00 p.m. at 8 positions around the cage periphery and the number of emergent beetles in each position on the cage walls was recorded.

A prounounced photopositive orientation of emerging beetles was evident (Table 2). The apparent aversion to the highest light intensity from 4:00 to 8:00 p.m. (Table 2) apparently is an artifact caused by the reluctance of beetles in a corner position of the cage to move as the sun shifted in position. In a laboratory choice chamber, a few tests also revealed a strong response to light at both 100% and 0% R.H. However, no heat controls for the light source were included. The photopositive nature of emergent brood beetles suggests that they may respond to visible or ultraviolet radiation and may be susceptible to manipulation with such stimuli at this stage of their life.

Relative Humidity Alternatives %	Females		Males	
	Light	Dark	Light	Dark
Controls				
77-77	50.2	-	48.0	-
Experimentals				
0-34	48.8	45.9	50.4	58.5
0-77	60.5	59.7	62.9	75.1
0-100	64.5	69.1	59.1	67.1

Table 1. Percent of emerged brood adult **Trypodendron lineatum** choosing the dry alternative when given a choice of 2 relative humidities under light and dark conditions. Mean of 2 replicates of 20 beetles for each test.

Time of Observation	Mean Temperature in Cage (C°).	No. beetles on walls of cage at positions ranked by decreasing light intensity for each time period.							
		1	2	3	4	5	6	7	8
12-1	17.4	5	-	-	-	-	-	-	-
1-2	18.3	16	2	1	-	-	-	-	-
2-3	19.1	29	3	2	-	-	-	-	-
3-4	20.4	38	3	2	-	-	-	-	-
4-5	25.2	4	37	12	1	-	-	-	-
5-6	28.9	6	25	20	1	-	-	-	-
6-7	28.9	7	18	16	-	-	-	-	-
7-8	24.3	10	26	9	-	-	-	-	-
8-9	19.4	8	5	16	-	-	-	-	-

Table 2. Orientation of emerged brood adult **Trypodendron lineatum** to light in a field cage.

The humidity and photic responses of brood *T. lineatum* were very different from those of parent beetles excised from host logs (Pulliainen 1965). Reproducing parents were strongly photonegative at high humidity levels, and were very hygropositive, being able to discriminate between 100 and 97% R.H. The difference in orientation can be explained through an examination of the biology of the 2 stages. Reproducing parents remain in dark galleries and rely heavily on moist conditions for both direct survival and fungus cultivation. However, brood beetles emerge into an environment which must be dry and well lighted to enable them to fly to an overwintering location and perceive a dark and moist site in which to overwinter.

It is evident that reversals in both photic and humidity response occur in brood beetles. To locate and remain in the overwintering site, they must become photonegative and hygropositive. The shift in photic to chemotactic response in spring beetles occurs after a prerequisite period of flight (Graham 1959, 1960; Bennett and Borden 1971) and as in *Dendroctonus pseudotsugae*, may also be associated with lipid content (Atkins 1966a, b, 1969) and selective lipid oxidation (Thomposn and Bennett 1971). Such physiological activity could provide an effective, internal feedback mechanism which would allow a behavioral reversal only after an insect had achieved a desired physiological condition. The known or postulated mechanisms controlling behavioral reversals in spring beetles may lead to effective means of investigating the reversals of photic and humidity response in brood *Trypodendron lineatum*.

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Dempsey, M. W. Ed-in-Chief

THE WORLD OF INSECTS

Reference Library Books
Curtis Circulation Co.
Philadelphia. 1971
60c

From time to time this society has debated proposals to publish an elementary handbook on insects of the province for use in schools. Committees have even been struck to begin writing, but no manuscript has been forthcoming. Probably the members discovered that it is extraordinarily difficult to produce a regional guide to insects for young readers who are making a standing start. Some basic knowledge has to be assumed or provided. The two levels of information are not easy to combine into a small book and always there is the problem of illustration.

Now appears another rock-bottom elementary booklet, not slanted to this area admittedly, but at 60c priced below anything this society could hope for, well and interestingly written without gee-whiz superlatives, brilliantly illustrated in color to the Queen's taste, and factual enough for Chas. Darwin himself. It is one of a series of 12 (Birds, Fishes, The Earth, etc.). The cover blurb reads: ". . . Over 80 full-colored pictures. In dictionary form for quick, easy reference. All fundamentals and essential facts for a basic grasp of subject. An implement for educational advancement." All true.

The problem in writing such as this is one of choice: what to use from the mountains of available information, so that the beginner is not bored and turned off. Here the statements are so attractively illustrated as to lessen the importance of the examples chosen. Moreover, despite a faint British flavor, the examples are mostly so general that we have in this province similar forms or relatives close enough to recognize.

All the land arthropods are touched on, including three pages on spiders. There is a two-page index, an excellent family tree of 15 Orders of insects from Collembola up, and a table of 24 Orders organized by metamorphosis, with round numbers of species in each. One page is devoted to collecting methods.

The question remains: should we still try to produce a handbook for B.C. schools or rely on such books as this? The problem resolves itself into three parts: What information to present? How to illustrate it? Who should pay?

H. R. MacCarthy

EARLY BIOLOGICAL CONTROL ATTEMPTS IN CANADA

B. P. BEIRNE[1] AND J. S. KELLEHER[2]

ABSTRACT

Seven attempts at biological control by introduction were made against six species of insects in Canada in 1882 to 1907. None apparently was successful.

Biological control attempts in Canada since 1910 were reviewed by McLeod, McGugan, and Coppel (1962) and in C.I.B.C. Technical Communication No. 4 (1971) and were evaluated by Turnbull and Chant (1961) and Munroe (1971). Earlier attempts were, however, omitted. They are reviewed here because most of the target species were not subjects of attempts after 1910.

Nematus ribesii (Scop.), the imported currantworm, was the subject of the first recorded biological control attempt by introduction in Canada. In 1882 Saunders imported into Ontario from New York eggs of *N. ribesii*that contained what is now known as *Trichogramma minutum* Ril. (Hym.: Chal.) and placed them near newly-laid eggs in the field, presumably near London, Ontario (Saunders, 1882). The consequences were not recorded, but it is highly unlikely that *T. minutum* was not already widespread in Ontario.

Another attempt against *N. ribesii* was made in 1892. Eggs parasitized by a *Trichogramma* sp. from Arnprior, Ontario, were distributed by Fletcher in gardens in the vicinity of Ottawa where, however, he soon found that the parasite "was already present in strong force" (Fletcher, 1893). Thus the attempt was redundant.

Phytophaga destructor (Say), the Hessian fly, was the subject of the first apparent attempt with an agent imported from overseas. In 1891 Hessian fly pupae containing *Pediobius epigonus* (Walk.) (Hym.: Chal.) were imported into the United States by Riley who sent some to Forbes in New York State, and Forbes in turn sent some to Fletcher at Ottawa (Forbes, 1891; Riley, 1892). It is not clear from the literature (Riley, 1893; Howard, 1895) whether or not Fletcher actually liberated those parasites. If he did, there is no indication that the species became established in Canada as a result. A record of this parasite from Prince Edward Island in 1898 (Fletcher, 1900) is questionable (Peck, 1963), and anyway if correct could not reasonably have originated from a liberation in Ontario two years previously. This biological control attempt thus can be safely classed as a failure.

In 1896 Fletcher (1897) imported from California apricot scales, *Lecanium armeniacum* Craw., containing *Encyrtus fuscus* How. (Hym.: Chal.). Some of the parasites were liberated in Ottawa in an elm tree that had an infestation of a *Lecanium* sp. This biological control attempt was redundant as the parasite was known to occur already in the Ottawa district: in Hull, Quebec, in 1887, as *Chiloneurus maculatipennis* Prov. (according to Peck, 1963).

The remainder of the *Encyrtus fuscus* material was sent to Grimsby, Ontario, to be liberated against what is now known as *Lecanium tiliae* L., the European fruit lecanium (Fletcher, 1897). It is not clear whether or not it was actually liberated. If it was, the liberation probably was redundant because of the likelihood that the parasite was already in Ontario (see above). Records for it from a species of *Lecanium* in Ontario in 1901 (Fletcher, 1902) and from *L. tiliae* (as *L. corni* Bouche) in Ontario in 1910 (Jarvis, 1911) are most unlikely to have arisen from the possible liberation of 1896.

In or before 1907 Fletcher (1907) introduced specimens of *Lepidosaphes ulmi* (L.), the oystershell scale, that contained a fungus from Nova Scotia into a locality in western Ontario where *L. ulmi* and *Quadraspidiotus perniciosus* (Comstock), the San Jose scale, were common, but neither became infected there.

None of the seven attempts against the six species could be evaluated as even possibly successful and most of them probably were redundant in that the introduced agents probably were already inhabitants of the regions where they were liberated. Two of the six target species, *L. tiliae* and *L. ulmi*, were subjects of subsequent attempts, after 1910, but with different agents from those mentioned above.

[1]Pestology Centre, Department of Biological Sciences, Simon Fraser University, Burnaby 2, B.C.

[2]Scientific Information Section, Canada Department of Agriculture, Ottawa, Ont.

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Lester A. Swann &
Chas A. Papp
1972

THE COMMON INSECTS OF NORTH AMERICA

Harper & Row, Publishers
Inc. Pp xiii & 750

This is a very courageous undertaking, and on the whole a successful one. The purpose is nothing less than to provide "an easy way to identify the more common insects of North America north of Mexico". It is the next logical step beyond Essig's ***Insects of Western North America,*** and is perhaps more usable by laymen. The concept is that of a simple, swift introduction to insects as animals, their characteristics, biology and value; a short pictured key to Orders; then the descriptions of Ametabola (6 spp.), Paurometabola (169 spp.), and Holometabola (996 spp.); a list of families represented; a 14-page glossary; a general bibliography, up-to-date and well chosen; and a technical taxonomic bibliography, by and for specialists. Canadians and C.D.A workers are very well represented, especially in the latter. There are two indexes: subjects and common names (14 pp.); and scientific names (24 pp.).

The line drawings are always across the top of the page, a useful idea for quick reference. An adult of every one of the 1171 spp. is illustrated. Often there is more than one drawing per species, showing an egg, a larva or a pupa, venation, habitus, etc. On average each insect is shown from one to two inches long, with a size scale given, unfortunately, I think, in inches taken to two places of decimals for minute forms. Few available rulers show inches in tenths, much less in hundredths. Surely millimeters would have been a more useful scale, and certainly one with a better future? However, it should not be a great task to convert the figures for some future edition. The description is generally opposite or below the drawing on the same page. Ranges are given with utmost economy in the text.

A bonus is a centre section of 8 pages in color, showing such lepidopterous goodies as swallowtails, a cecropia, a monarch and a viceroy, admirals, fritillaries, polyphemus, imperial and cynthia moths, and a small, colorful selection of bees, wasps, beetles and three flies.

The authors are Californians, and the foreword is by Dr. Evert I. Schlinger, of the University of California at Berkeley.

H. R. MacCarthy

THREE SPECIES OF COLEOPTERA NEW TO BRITISH COLUMBIA

W. LAZORKO

At Osoyoos on July 1, 1972 I found the first authentic British Columbia specimens of the hollyhock weevil, *Apion longirostrie* Ol. (Apelmonini : Curculionidae). This well-known palearctic species, native to southern and southeastern Europe, Asia Minor and Persia (Iran), was first found in North America in 1914. According to Hatch (1971) it is now widespread over the United States. It reached the Pacific Northwest in 1966 and is known from eastern Washington and western Oregon.

I noted a number of hollyhocks, *Althea rosea* Chevr., in a garden with the leaves badly damaged by small round holes. Close inspection revealed a colony of the hollyhock weevils, many in copula, crawling on the leaves, stems and flower buds. The females, which were easily recognizable by the extremely long rostrum, which is longer than the rest of the body, were burrowing into the buds, and both sexes were feeding on the leaves. Hundreds of weevils, in perfect condition, were seen in this garden and on other hollyhocks close by. A search elsewhere in Osoyoos produced no further specimens.

It is impossible to say if this occurrence indicates a recent immigration or if the species was present earlier, but overlooked. I saw none in this area in 1966 or 1967. Since I have numerous specimens from the Ukraine and Persia in my collection, I took only 24 specimens, hoping that this *Apion* would become established here. One pair has been deposited in the University of British Columbia collection, and one pair in Mr. J. Grant's collection at Vernon.

The species of the genus *Phyllotreta* (Halticini:Chrysomelidae) are insufficently known. Many are inconspicuous, small and dull-looking and do not attract the attention of entomologists. Being particularly interested in the holarctic aspect of the genus, I was pleased to find two species new to British Columbia. *P. utana* Chitt, is a large vittate American species, recorded by Chittenden (1927) from Utah, Nevada, Oregon and Montana and by Hatch from western Montana and Oregon. One female was taken by Mr. G. H. Larnder at Errington, on Vancouver Island, August 9, 1931 and determined by Professor L. G. Gentner (in *coll. mea*). I collected three females at Essondale, on March 31, 1969; April 8, 1969; and June 16, 1971. All were creeping on the east-facing wall of a building. According to Chittenden the host plant is most likely hedge mustard, *Sisymbrium* sp. The repeated though sporadic occurrence of this species and its occurrence in two widely separated localities indicates that it is probably a native insect; its apparent rarity in British Columbia may perhaps be due to its being near the northernmost extremity of its range.

Phyllotreta armoraciae Koch. is a native of Europe which was first collected in North America in 1893. It was first recorded from the Pacific Northwest by Schuh, in northern Idaho, in 1960 (Hatch 1971). I took one specimen of this easily recognizable species on the wall of a building at Essondale on June 17, 1968. The host plant is horseradish, *Armoracia lapathifolia* Gilib. (=*Cochlearia armoracia* L.), and it appears that the beetle is a monophage of this introduced plant. No horse radish grows in Essondale but it is possible that it is cultivated in nearby Port Coquitlam. The specimen collected could have flown in from that locality, carried on an easterly wind, or perhaps, because of the proximity of the railroad to the building, it was imported recently from eastern North America on a freight train.

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NOTES ON THE COLEOPTERA OF WRACK

I. MOORE[1]

The early stages of a number of beetles of intertidal rock crevices and salt marshes in southern California have been studied (Moore 1956, 1964a, 1964b; James *et al.* 1971). The coleopterous fauna of wrack is much more conspicuous and abundant than that of the habitats mentioned. Nevertheless, in spite of considerable investigation, the biologies of most of the insects of wrack remain unknown.

Seaweed cast up on the beach and left unwetted by seawater for a few days is usually teeming with adult beetles of many species which are indigenous to decaying kelp. Only occasionally are larvae encountered and those are of a few species only. When the wrack is again wetted by a high tide the adult insects leave; the action of the rare larvae is not known. The interval between highest tides which is the interval during which the insects gradually appear and suddenly disappear, is of about 16 to 20 days at most. This interval is too short for the development of most of these beetles. Their breeding sites must, therefore, be elsewhere; there are several possible sites. Three are discussed here.

Tiger beetles (*Cicindela* spp.) are often common on sandy beaches. It is known that larvae of such species occur on salt marshes of bays and estuaries (W. D. Sumlin, III, personal communication). It is possible that some species of beetles found in decaying seaweed also breed in salt marshes and that the adults fly to decaying seaweed for food. Although I have investigated salt marsh insects without encountering any wrack inhibiting species, the matter still needs further investigation.

[1]Division of Biological Control, University of California, Riverside 92502.

The intermittent streams of coastal southern California are more numerous than the salt marshes. The mouths of these streams are usually closed by sand bars behind which are often ponds or lagoons of fresh, slightly brackish or occasionally highly saline water. The insect fauna at the margins of such ponds is distinctive but it includes species found at the margins of streams and ponds inland. Since larval forms of only a few of these insects are known, some insects of the wrack might breed here and be unrecognized.

A third possibility is that some of the insects of the wrack develop in the damp sand of beaches. We know it to be true of at least some species of *Cafius* (James *et al.* 1971). This hypothesis could be tested, laboriously, by trenching the beach at intervals and extracting the arthropods with a berlese funnel. Sample digging with sea water floating for extraction was unsuccessful on several occasions but the insects might have been so widely dispersed that they were overlooked.

Certain species of Coleoptera are often so abundant in wrack that it seems incredible that the early stages are still unknown in spite of years of searching.

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THE APHIDS (HOMOPTERA: APHIDIDAE) OF BRITISH COLUMBIA. 1. A BASIC TAXONOMIC LIST[1]

A. R. FORBES, B. D. FRAZER AND H. R. MACCARTHY
Research Station, Agriculture Canada
Vancouver 8, British Columbia

ABSTRACT

A list is presented of 213 species of aphids collected from 255 hosts or in traps in British Columbia.

INTRODUCTION

This paper lists most of the aphids now known to occur in British Columbia with their host plants. A survey to assess the relative abundance and importance of aphids in the province was begun by the senior author in 1957. Extensive collecting from commercial crops, weeds, and wild hosts has been carried out each year since and Moericke yellow pan water traps were maintained at several locations in the lower Fraser Valley in some years.

Aphids occur on virtually every crop grown in the province. Some aphids damage their hosts directly by their feeding, whereas others are more important as vectors of virus diseases. Until very recently even some of our pest species have been incorrectly identified and little was known of the many species that breed on crops in small numbers. The latter are often important as virus vectors. Conversely, knowledge of the host range, including wild hosts, of vector species is often important in the epidemiology of plant diseases.

Glendenning (1924, '25, '29) listed 117 species of aphids in British Columbia. Unfortunately the nomenclature of his lists is out-of-date and the status of some of his species is in question. Work is underway to up-date his records and the results will be published as soon as possible.

The present list includes collections made in connection with the aphid survey project of the Vancouver Research Station along with the records of B.C. material published by W. R. Richards (Richards 1956-1972, see References). Most of the collections were made by the authors. About 30 collections were made and given to us by the late Prof. G. J. Spencer of the University of British Columbia. Other collectors include: H. Andison, G. V. Armstrong, F. L. Banham, S. K. Burt, E. C. Cole, R. A. Costello, W. T. Cram, H. A. Daubeny, L. Farstad, G. J. Fields, D. G. Finlayson, J. D. Fitz-Gerald, R. E. Fitzpatrick, H. G. Fulton, R. Glendenning, K. Graham, R. H. Handford, R. Harris, J. R. Hill, R. G. Jones, R. Marlatt, F. C. Mellor, R. P. Messum, J. Moisey, C. L. Neilson, M. D. Noble, D. Ormrod, W. D. Pearson, H. S. Pepin, D. P. Pielou, J. Raine, E. Ruddock, G. G. E. Scudder, H. Severson, F. E. Skelton, M. G. Smuin, R. Stace-Smith, H. N. W. Toms, N. Tonks, W. D. Touzeau, P. Townsley, W. H. Wilde, A. T. Wilkinson and N. S. Wright.

Most of the identifications were made by W. R. Richards, Taxonomy Section, Entomology Research Institute, Ottawa, or by the senior author; some were by B. D. Frazer. Several of the *Cinara* species were identified by G. A. Bradley. All the specimens recorded are in the collection at the Research Station at Vancouver or in the Canadian National Collection at Ottawa.

The aphids were collected in 80% ethanol. Clearing and mounting were done by the method of Hille Ris Lambers (1950), which has also been reported in this Journal by Spencer (1959).

Most of the aphids are given with the host plants on which they were collected. A few species were collected only as stray alates on plants other than their normal hosts. These species are listed as "in flight". Species collected from Moericke yellow pan traps are listed only when that species has not been taken breeding on a host plant. Further collecting will undoubtedly associate the aphids in both the latter categories with their host plants.

The aphids are listed alphabetically by species. This gives a convenient and speedy method of reference and eliminates the problem of having to look in several places for a species that is placed in different genera by different authorities. Host plants are listed alphabetically by genus and species. The location of the collection sites may be determined by reference to Table 1 and the map of the province (Fig. 1).

Plant names follow Conners (1967), Toms (1964), or Henry (1915). Many of the host plants were identified by H. N. W. Toms.

[1]Contribution No. 270, Research Station, 6660 N.W. Marine Drive, Vancouver 8, British Columbia.

ECOLOGICAL BACKGROUND

Since it includes 1500 kilometers or nearly 1000 miles of the Cordillera, British Columbia is predominantly mountainous, the ranges running generally northwest and southeast. Covering 948,600 sq km (366,255 sq mi), the province is roughly halved by the 54th parallel. It has boundaries of 1,046 km (650 mi) with the N W Territories and Yukon along the 60th parallel on the N, and 644 km (400 mi) with the states of Washington, Idaho and Montana along the 49th parallel on the S. From the 49th to the 60th parallel is 1,207 km (750 mi). There are 7,164 km (4,450 mi) of indented coastline and 4,830 km (3,000 mi) of major rivers, many of which run in deep canyons. Forests cover 39% of the province and barren rock 53%; 2% is in rivers and lakes, 2% is upland range and grazing. Only 3% is arable or potentially so and most of this is essentially prairie parkland, lying to the E and N of the Rockies along the border with Alberta and N of the 55th parallel (Atlas of Resources, 1956). There are two general types of climates: maritime on the W side of the Coast Mountains, with high winter precipitation and cool summers; continental in the interior, tending to semi-arid in the S and sub-arctic in the N.

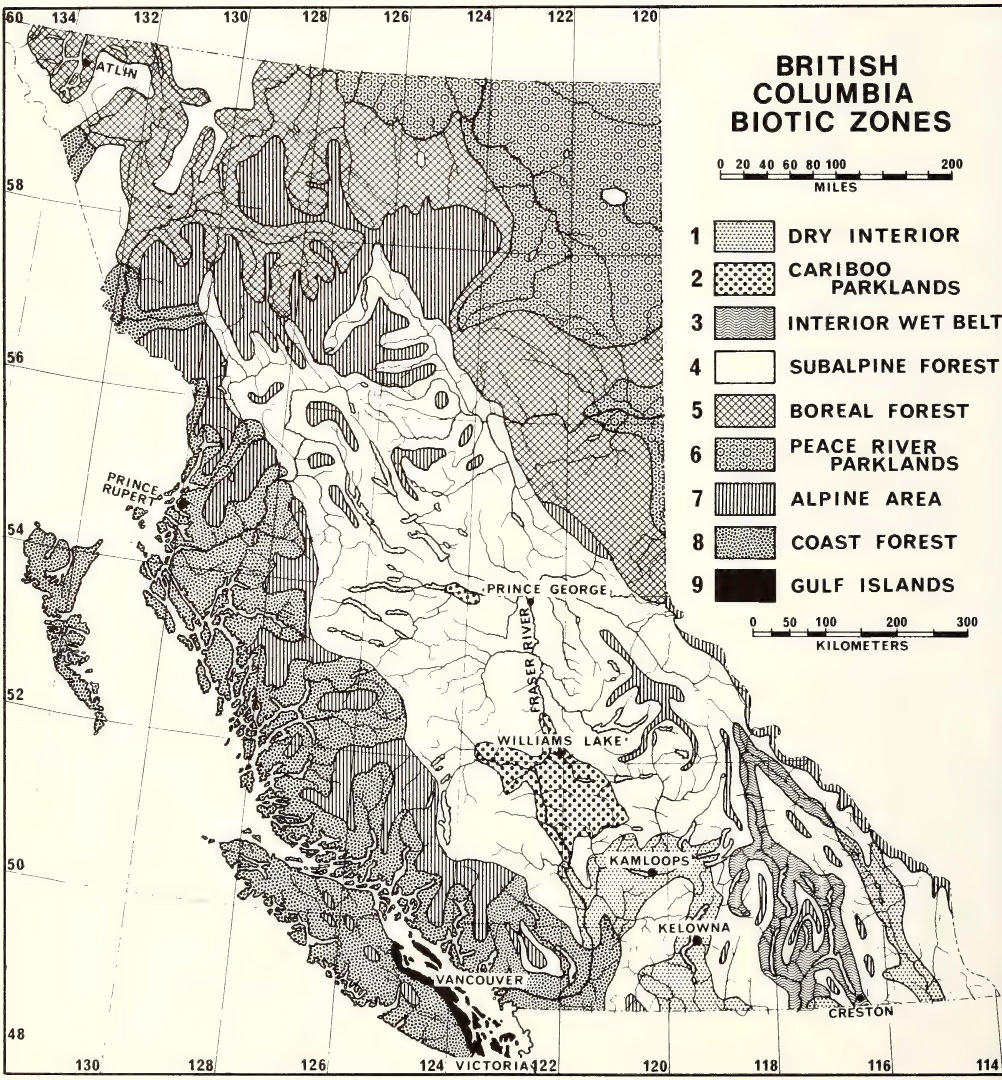

Fig. 1. Biotic zones of British Columbia, adpated from those of Munroe and Cowan (1947) by Lyons (1965).

Table 1. Localities where aphids were taken with airline distances from reference points. The 8 places used as reference points and the biotic zones appear on the map (Fig. 1). Kilometers and miles are rounded to the nearest whole number.

Locality	Biotic zone	Reference point	Dir.	Distance km	Distance mi
Abbotsford	8	Vancouver	SE	64	40
Agassiz	8	Vancouver	E	97	60
Aldergrove	8	Vancouver	SE	48	30
Atlin	5	Extreme NW			
Barnhartvale	1	Kamloops	E	15	9
Bella Coola	8	Williams Lake	W	277	190
Boundary Bay	8	Vancouver	S	32	20
Bowser	9	Victoria	NW	153	95
Bradner	8	Vancouver	SE	56	35
Brentwood	9	Victoria	NW	29	18
Britannia Beach	8	Vancouver	N	48	30
Burnaby	8	Vancouver	E	1	1
Burns Lake	4	Prince George	W	193	120
Cache Creek	1	Kamloops	W	68	42
Campbell River	9	Victoria	NW	230	143
Canyon	1	Creston	E	8	5
Chase	1	Kamloops	E	48	30
Chilcotin	2	Williams Lake	W	120	75
Chilliwack	8	Vancouver	E	88	55
Cloverdale	8	Vancouver	SE	32	20
Courtenay	9	Victoria	NW	225	140
Cowichan Bay	9	Victoria	N	40	25
Creston	1	Vancouver	E	468	297
Creston Flats	1	Creston	W	1	1
Duncan	9	Victoria	N	40	25
Erickson	1	Creston	E	6	4
Fawn	2	Williams Lake	SE	77	48
Fort St. John	6	Prince George	NE	282	175
Goldstream	9	Victoria	NW	24	15
Grand Forks	1	Kelowna	SE	129	80
Hat Creek	1	Kamloops	W	97	60
Kamloops	1	Vancouver	NE	249	155
Kelowna	1	Kamloops	SE	113	70
Ladner	8	Vancouver	S	24	15
Langford	9	Victoria	W	13	8
Langley	8	Vancouver	E	40	25
Lillooet	1	Kamloops	W	113	70
Lister	1	Creston	S	6	4
Lulu Island	8	Vancouver	S	16	10
Lumby	1	Kelowna	NE	53	33
Manning Park	7	Vancouver	E	217	135
Merritt	1	Kamloops	S	71	44
Milner	8	Vancouver	SE	35	22
Mission	8	Vancouver	E	58	36
New Westminster	8	Vancouver	SE	3	2
North Vancouver	8	Vancouver	N	8	5
Oliver	1	Kelowna	S	72	45
Pavilion Lake	1	Kamloops	W	105	65
Pemberton	8	Vancouver	N	129	80
Penticton	1	Kelowna	S	26	16
Pitt Meadows	8	Vancouver	E	29	18
Prince Rupert	8	Vancouver	NW	708	440
Prospect Lake	9	Victoria	N	13	8
Pt. Atkinson	9	Vancouver	W	16	10
Queen Charlotte	8	Prince Rupert	SW	161	100
Quesnel	2	Prince George	S	84	53
Rayleigh	1	Kamloops	N	16	10
Revelstoke	3	Kelowna	NE	156	97
Richmond	8	Vancouver	S	16	10
Rykerts	1	Creston	S	10	6
Saanich	9	Victoria	N	24	15
Sardis	8	Vancouver	E	84	52
Sea Island	8	Vancouver	S	8	5
Soda Creek	2	Williams Lake	N	27	17
Sorrento	1	Kamloops	NE	64	40
South Burnaby	8	Vancouver	E	1	1
Sumas	8	Vancouver	SE	69	43
Summerland	1	Kelowna	SW	35	22
Summit Lake	4	Prince George	N	45	28
Terrace	8	Prince Rupert	E	116	72
Texas Lake	8	Vancouver	E	124	77
Trail	1	Vancouver	E	396	246
Vancouver	8	Mouth of Fraser R			
Victoria	9	SE tip Vancouver Is			
Westham Island	8	Vancouver	S	24	15
Williams Lake	2	Kamloops	NW	209	130

We have adopted the 9 biotic zones of Lyons (1965) (Fig. 1), which are themselves somewhat simplified from the 13 of Munro and Cowan (1947). Lyons describes the zones clearly and gives separate lists of the native common trees, shrubs and flowering plants occurring in each. Woody plants are described and keyed in more detail by Garman (1963). The grasses in the province are covered effectively and in detail by Hubbard (1955), the ferns by Taylor (1956), the mosses by Schofield (1969) and the weeds by Frankton and Mulligan (1970). The region as an environment for insects is described in general by Munroe (1956).

The biotic zones apply most directly to valley bottoms, where communications generally run and where tillage agriculture is practiced. Even in the most arid, southerly part of the Okanagan Valley it is possible within a short distance on the map, to climb into different zones and even into alpine surroundings. Thus a locality label may bear the name of a place in a given zone, but the specimen may have been taken in a different zone, hundreds of meters higher. It follows that conventional range maps are of limited value.

During the Wisconsin glaciation the province, including even the outlying Queen Charlotte Islands, was completely buried without refugia, to depths up to 2,500 m (8,400 ft) (Atlas of Resources, 1956). In the ensuring period a fairly large number of aphid species have moved into the province but many of the 213 species recorded here are introductions, associated in some way with agriculture or horticulture.

The extent and diversity of the province suggest that its aphid fauna is unlikely to be fully known in the near future.

The name of each place where an aphid species occured is listed in Table 1, with the number of its biotic zone (Fig. 1) and its airline distance and direction from 8 reference points.

LIST OF SPECIES

ABIETICOLA (Cholodkovsky), CINARA
Abies sp: Victoria, Jun 6 67.

ABIETINUM (Walker), ELATOBIUM

Picea pungens: Vancouver, Apr 15 / 58.
Picea sitchensis: Prince Rupert, Apr 26 / 26; Richmond, May 20 / 64.
Picea sp: North Vancouver, May 30 / 60; Vancouver, Apr 27 / 61.

ABIETINUS Koch, MINDARUS
Abies grandis: Vancouver, Jun 8 / 67.

AEGOPODII (Scopoli), CAVARIELLA
Anethum graveolens: Richmond, Jul 12 / 65; Vancouver, Aug 9 / 56.
Daucus carota: Agassiz, Jul 28 / 59; Cloverdale, Jul 4 / 57, Nov 25 / 64; North Vancouver, Sep 8 / 72; Vancouver, Jul 10 / 62; Victoria, Aug 2 / 65.
Oenanthe sarmentosa: Victoria, Aug 2 / 65.
Sium suave: Williams Lake, Aug 7 / 65.

AETHEOCORNUM (Smith & Knowlton), MACROSIPHUM
Geranium viscosissimum: Williams Lake, Aug 4 / 58.

ALBIFRONS Essig, MACROSIPHUM
Lupinus sp: Mission, Jun 15 / 57; North Vancouver, Jul 15 / 65; Vancouver, May 26 / 58, May 30 / 57.

ALBIPES Richards, THELAXES
Quercus garryana: Victoria, May 7 / 63 (Richards 1966a), Jun 7 / 67.

ALNI (DeGeer), PTEROCALLIS
Alnus rubra: Prince Rupert, Jul 10 / 60 (Richards 1965); Vancouver (UBC), Aug 24 / 62.
Alnus sp: Oliver, Jul 4 / 59 (Richards 1965).

ALPINA (Gillette & Palmer), KAKIMIA
Moericke yellow pan water trap: Chilliwack, Aug 9 / 67; Richmond, Sep 2 / 67.

AMBROSIAE (Thomas), DACTYNOTUS
Aster sp: Vancouver, Jun 18 / 57.

AMERICANUM (Riley), ERIOSOMA
Ulmus sp: Kamloops, Jun 10 / 57.

AMSINCKII Richards, PLEOTRICHOPHORUS
Amsinckia intermedia: Oliver, Jul 18 / 65 (Richards 1968a).

ASCALONICUS Doncaster, MYZUS
Allium schoenoprasum: Vancouver, Sep 30 / 63.
Aubrieta deltoidea: Victoria, Apr 4 / 58.
Aucuba japonica: Vancouver, May 22 / 67.
Capsella bursa-pastoris: Vancouver (UBC), Apr 17 / 67.
Cardamine oligosperma: Vancouver (UBC), Apr 26 / 67.
Erodium cicutarium: Vancouver (UBC), Apr 26 / 67.
Fragaria chiloensis var *ananassa:* Abbotsford, Mar 17 / 61; Saanich, Jun 5 / 59; Sumas, Mar 4 / 58; Vancouver, Jan 22 / 68, Apr 2 / 58, Apr 8 / 58; Apr 17 / 59, May 17 / 57; Vancouver (UBC), Mar 3 / 67, Oct 10 / 69, Oct 18 / 69; Victoria, Mar 13 / 57, Apr 13 / 57.
Geranium molle: Vancouver (UBC), May 3 / 67.
Geum macrophyllum: Vancouver, Jun 9 / 67.
Heracleum maximum: Vancouver, Feb 4 / 58.
Hesperis matronalis: Vancouver, Jun 9 / 67.
Hypochaeris radicata: Vancouver (UBC), Apr 28 / 67.
Lilium speciosum: Vancouver, Mar 1 / 58.
Osmorhiza chilensis: North Vancouver, May 18 / 64.
Plantago lanceolata: Vancouver (UBC), May 3 / 67.
Rumex acetosella: Lulu Island, Apr 10 / 67; Vancouver (UBC), Apr 17 / 67.
Sisymbrium officinale: Vancouver, Mar 28 / 58.
Sonchus sp: Vancouver (UBC), Apr 26 / 67.
Stellaria sp: Vancouver, Jul 22 / 59.
Taraxacum officinale: Vancouver (UBC), Apr 26 / 67.
Viola tricolor: Abbotsford, Mar 17 / 61; Vancouver, Jan 18 / 58, Jun 6 / 67, Dec 30 / 57.

ATRIPLICIS (Linnaeus), BRACHYCOLUS
Chenopodium album: Lulu Island, Aug 2 / 56; Quesnel, Aug 7 / 67; Soda Creek, Aug 5 / 58; Victoria, Aug 2 / 65, Aug 8 / 56.

AVENAE (Fabricius), MACROSIPHUM
Agropyron sp: Creston, Aug 13 / 59; Vancouver, Aug 3 / 58.
Avena sativa: Vancouver, May 29 / 58, Aug 20 / 57.
Gramineae: Vancouver, Apr 12 / 58.
Hordeum vulgare: Creston, Jul 4 / 57.
Secale cereale: Vancouver, May 8 / 59; Victoria, Apr 7 / 58.
Triticum aestivum: Creston, Jul 20 / 57, Jul 24 / 57; Fort St. John, Aug 64; Vancouver, May 9 / 58, Aug 1 / 59, Aug 9 / 56; Vancouver (UBC), Jun 20 / 67.
Zea mays: Chilliwack, Nov 20 / 56.

BAKERI (Cowen), ROEPKEA
Malus sylvestris: Vancouver, Sep 1 / 57.
Trifolium sp: Vancouver, Aug 26 / 70.

BERBERIDIS (Kaltenbach), LIOSOMAPHIS

Berberis thunbergii: Vancouver, May 30 / 65, Jul 15 / 64.

BETULICOLA (Kaltenbach), CALAPHIS
Betula papyrifera: Vancouver, May 12 / 61, Oct 4 / 60.
Betula sp: Summerland, Jul 7 / 69.

BETULIFOLIAE Granovsky, CEPEGILLETTEA
Betula occidentalis: Merritt, Aug 10 / 24 (Richards 1969a).

BICOLOR BICOLOR (Oestlund), PTEROCOMMA
Populus balsamifera: Atlin, Jun 1 / 55.
Populus trichocarpa: Sardis, Apr 8 / 26.
Salix sp: Langford, Jun 9 / 59; Summit Lake, July 4 / 59, Aug 20 / 59; Terrace, Jul 13 / 60.
All records from Richards (1967c).

BRAGGI (Gillette), CINARA
Picea pungens: Vancouver, Jun 11 / 70.

BRASSICAE (Linnaeus), BREVICORYNE
Brassica napobrassica: Cloverdale, Jul 31 / 56; Victoria, Aug 8 / 56.
Brassica oleracea var *capitata:* Creston, Sep 16 / 58; Vancouver (UBC), May 22 / 58, Aug 8 / 56.
Brassica oleracea var *gemmifera:* Agassiz, Jul 16 / 58; Vancouver (UBC), Oct 20 / 60.
Rhaphanus sativus: Barnhartvale, Oct 4 / 56.

BREVISPINOSA (Gillette & Palmer), CINARA
Pinus contorta: Agassiz, Jul 26 / 33; Fawn, Jun 23 / 52 (Richards 1956).

BREVISPINOSUS Gillette & Palmer, PERIPHYLLUS
Acer glabrum: Kelowna, Jun 8 / 57.

BULBOSA Richards, PLOCAMAPHIS
Salix sp: Oliver, Jun 29 / 65, Jul 17 / 65 (Richards 1966b).

BURSARIUS (Linnaeus), PEMPHIGUS
Moericke yellow pan water trap: Richmond, Jul 6 / 64, Sep 29 / 64.

CALIFORNICA (Davidson), THELAXES
Quercus garryana: Victoria, Jun 2 / 67.

CALIFORNICUM (Clarke), MACROSIPHUM
In flight: Ladner, Jun 7 / 56.

CALIFORNIENSIS (Shinji), PERIPHYLLUS
Acer circinatum: Chilliwack, May 7 / 59.
Acer sp: Chilliwack, May 28 / 59.

CANAE (Williams), APHIS
Artemisia tridentata: Kamloops, Jun 2 / 60, Aug 11 / 60; Pavilion Lake, Aug 2 / 60; Rayleigh, Aug 18 / 60.

CARDUI (Linnaeus), BRACHYCAUDUS
Cirsium undulatum: Chase, Jul 25 / 67.
Prunus domestica: Sorrento, May 14 / 58.

CARDUINUS (Walker), CAPITOPHORUS
In flight: Creston Flats, Aug 13 / 58; Soda Creek, Aug 5 / 58.
Moericke yellow pan water trap: Richmond, Jul 6 / 69.

CARPINI (Koch), MYZOCALLIS
Carpinus betulus: Vancouver, Jun 15 / 64.

CASTANICOLA Baker, MYZOCALLIS
Castanea sp: Lulu Island, Aug 8 / 54 (Richards 1965).

CEANOTHI Clarke, APHIS
Ceanothus sanguineus: Mission, Jun 18 / 59.

CERASI (Fabricius), MYZUS
Prunus avium: Creston, Jun 5 / 57, Sep 16 / 58; Erickson, Jul 28 / 58, Sep 30 / 58.
Prunus emarginata: Vancouver, Jun 15 / 64.

CIRCUMFLEXUS (Buckton), AULACORTHUM
Iris sp: Vancouver, May 18 / 58.
Lilium longiflorum: Vancouver, May 2 / 61.
Pelargonium hortorum: Vancouver, Jul 7 / 59.
Primula sp: Vancouver, Jan 18 / 58.
Saintpaulia sp: Vancouver, May 26 / 56.
Tulipa gesneriana: Vancouver, May 24 / 58.
Viola tricolor: Vancouver, Jan 18 / 58, May 6 / 67.
Yucca smalliana: Vancouver, Jul 25 / 63.

CIRSII (Linnaeus), DACTYNOTUS
Cirsium arvense: Chilliwack, Jul 30 / 65; Cloverdale, Jul 31 / 65; Vancouver, Jul 15 / 65; Victoria, Aug 2 / 65.
Cirsium brevistylum: Summerland, Jun 30 / 69.
Cirsium sp: Vancouver, Jul 20 / 62.

CLAVICORNIS Richards, AULACORTHUM
Rosa sp: Oliver, Jul 1 / 65 (Richards 1972b).

COLORADENSIS (Gillette), CINARA
Picea pungens: Vancouver, May 25 / 59.

COLUMBIAE Richards, SITOMYZUS
Gramineae: Vancouver, May 7 / 58 (Richards 1960 b), May 19 / 58.

COLUMBIAE Richards, TUBERCULATUS
Quercus garryana: Langford, Jul 14 / 59

(Richards 1965, 1968b); Victoria, Jul 1/56.

CORNI (Fabricius), ANOECIA
Moericke yellow pan water trap: Richmond, Sep 2/64, Sep 23/64, Sep 26/64, Oct 12/64.

CORNIELLA Hille Ris Lambers, APHIS
Epilobium angustifolium: Richmond, Aug 4/58.
Epilobium sp: Williams Lake, Aug 4/58.

CORRUGATANS (Sirrine), PROCIPHILUS
Amelanchier sp: Soda Creek, Jun 16/56.

CORYLI (Goeze), MYZOCALLIS
Corylus avellana: Vancouver, May 22/56, Jun 22/56, Aug 8/56.
Corylus sp: Agassiz, Jun 18 24; Cowichan Bay, Jun 2/59; Creston, May/55, Jun/55; Langford, Jul 16/59; Summerland, Sep 18/57 (Richards 1965).

COSTATA (Zetterstedt), CINARA
Picea pungens: Vancouver, Jun 20/66.

COWENI (Hunter), MACROSIPHUM
Artemisia tridentata: Lillooet, Aug 3/60; Penticton, May 11/58.

CRACCIVORA Koch, APHIS
Laburnum anagyroides: Vancouver, Jun 26/61.
Spartium junceum: Vancouver (UBC), Jul 27/66.

CRATAEGARIUS (Walker), OVATUS
Mentha arvensis var *canadensis:* Vancouver, May 8/58.

CRATAEGIFOLIAE (Fitch), ROEPKEA
Leguminosae in summer and *Crataegus* spp in winter: (Richards 1969b).

CRYSTLEA (Smith & Knowlton), MASONAPHIS
Lonicera involucrata: Quesnel, Aug 6/58.

CURVIPES (Patch), CINARA
Abies balsamea: Agassiz, Aug 7/26.

CYPERI (Walker), TRICHOCALLIS
Carex spp: (Richards 1971).

CYTISORUM Hartig, APHIS
Cytisus demissus: Vancouver, Aug 2/63.

DACTYLIDIS (Hayhurst), HYALOPTEROIDES
Dactylis glomerata: Agassiz, Apr 22/58, May 26/59; Chilliwack, May 12/58; Vancouver, May 9/58.
Holcus lanatus: Richmond, May 24/64.

DAVIDSONI (Mason), MASONAPHIS
Rubus parviflorus: Vancouver, May 19/67, Jun 9/67, Jul 21/67; Vancouver (UBC), Aug 9/66.

DELICATUS Patch, CHAITOPHORUS
Populus spp: (Richards 1972c).

DIRHODUM (Walker), METOPOLOPHIUM
Avena sativa: Vancouver, Jul 10/57, Aug 20/57.
Crataegus sp: Vancouver (UBC), May 12/61.
Hordeum vulgare: Vancouver, Oct 15/65.
Rosa rugosa: Vancouver, Mar 28/58, Apr 3/58.
Rosa sp: Vancouver, Jan 6/58, Apr 8/58, Apr 12/58, Apr 28/57.

DORSATUM Richards, AULACORTHUM
Gaultheria shallon: Duncan, Jul 27/65 (Richards 1967b); Vancouver, Jun 29/67.

ELAEGNI (del Guercio), CAPITOPHORUS
Circium brevistylum: Summerland, Jun 30/69.
Mentha arvensis var *canadensis:* Williams Lake, Aug 7/58.

ERIGERONENSIS (Thomas), DACTYNOTUS
Grindelia stricta: Point Atkinson, May 5/57.
Solidago canadensis: (Richards 1972a).

ERIOPHORI (Walker), CERURAPHIS
Viburnum opulus: Vancouver, May 5/63, May 12/61; Victoria, Apr 4/58.

ERYSIMI (Kaltenbach), HYADAPHIS
Brassica campestris: Abbotsford, Aug 6/65.

ESSIGI (Gillette & Palmer), KAKIMIA
Aquilegia sp: Vancouver, Jun 27/63.

EUPHORBIAE (Thomas), MACROSIPHUM
Brassica oleracea var *gemmifera:* Agassiz, Jul 16/58.
Chrysanthemum morifolium: Victoria, Apr 4/58.
Cirsium arvense: Cloverdale, Jul 31/65.
Cornus nuttallii: Victoria, Jun 11/56.
Dicentra formosa: Goldstream, Aug 20/59.
Epilobium sp: Williams Lake, Aug 4/58.
Fragaria chiloensis var *ananassa:* Agassiz, May 5/57, May 12/56; Aldergrove, Jun 10/59; Langley, June 10/59; Richmond, May 3/57; Vancouver, Apr 8/58, May 18/61; Victoria, May 30/67.
Geum macrophyllum: Vancouver, Jun 9/67.
Gladiolus hortulanus: Vancouver, Jul 12/57; Williams Lake, Aug 12/58.
Heracleum maximum: Vancouver, Jun 14/55.

Holodiscus discolor: Vancouver, May 30/56.
Ilex aquifolium: Chilliwack, Apr 13/58; Vancouver, May 1/58, May 2/57; Victoria, Apr 4/58.
Lactuca pulchella: Creston, Jun 5/57.
Lactuca sativa: Vancouver, May 28/57, Sep 12/56.
Maianthemum dilatatum: Goldstream, Aug 20/59.
Malus pumila: Vancouver, May 23/58.
Matricaria matricarioides: Vancouver, May 29/59.
Medicago sativa: Kamloops, Jul 19/72.
Melilotus alba: Creston Flats, Jun 6/57.
Philadelphus gordonianus: Vancouver, May 26/59.
Rheum rhaponticum: Vancouver, Jul 20/65.
Rosa sp: Soda Creek, Aug 4/58; Vancouver, Mar 23/59.
Rubus idaeus: Agassiz, Sep 27/66.
Senecio vulgaris: Lulu Island, Apr 7/64.
Solanum tuberosum: Agassiz, Jul 12/56; Quesnel, Aug 7/67.
Tagetes erecta: Williams Lake, Aug 7/58.
Tulipa gesneriana: Chilliwack, May 13/58; Vancouver, Apr 7/58, May 4/59, May 14/59, May 17/67, May 24/58; Victoria, Apr 4/58, Jun 4/59.
Urtica lyalli: Summerland, Jun 30/69.
Zea mays: Chilliwack, Nov 20/56.
Zinnia elegans: Vancouver, Oct 7/58.

FABAE Scopoli, APHIS
Beta vulgaris: Vancouver, Jul 9/62.
Capsella bursa-pastoris: Abbotsford, Jul 21/66; Vancouver, May 5/56.
Chenopodium glaucum: Penticton, Sep 2/65.
Cirsium arvense: Abbotsford, Aug 30/51; Chilliwack, Jul 30/65; Texas Lake, Jul 24/67; Vancouver, Aug 2/65.
Euonymus alatus: Kamloops, May 15/67.
Gladiolus hortulanus: Vancouver, Aug 17/57, Aug 18/56, Sep 7/57.
Ilex aquifolium: Vancouver, Jun 7/59, Aug 13/62.
Lycopersicum esculentum: Creston, Aug 14/58; Victoria, Aug 2/65.
Matricaria matricarioides: Abbotsford, Aug 6/65.
Oxalis deppei: North Vancouver, Sep 15/63.
Philadelphus gordonianus: Vancouver, Jul 3/57, Sep 5/56.
Polygonum persicaria: Richmond, Aug 8/65.
Ranunculus sp: Abbotsford, Jul 19/65; North Vancouver, Sep 23/63.
Rheum rhaponticum: Grand Forks, Jul 20/61; Vancouver, Jul 29/65.
Solanum tuberosum: Victoria, Aug 12/53.
Sonchus asper: Saanich, Aug 21/59.
Tropaeolum majus: Vancouver, Aug 13/62.
Vicia faba: Vancouver, Aug 18/57.
Zinnia elegans: Vancouver, Oct 7/58.

FAGI (Linnaeus), PHYLLAPHIS
Fagus sylvatica: Vancouver, May 25 56.

FIMBRIATA Richards, FIMBRIAPHIS
Fragaria sp: Agassiz, Oct 11 56; Aldergrove, Jun 10 59; Richmond, May 22 57, May 23 58, Jun 2 58, Jun 18 57, Jul 17 57, Aug 2 56; Vancouver, Apr 17 59, Apr 24 59, May 18/61; Victoria, May 30/57.
Vaccinium corymbosum: Pitt Meadows, Jul 15/58; Richmond, May 15/65; Vancouver, May 23/58, Jun 25/63.
Vaccinium sp: Vancouver, May 11/59.

FITCHII (Sanderson), RHOPALOSIPHUM
Crataegus sp and *Malus* sp: (Richards 1960c).
Moericke yellow pan water trap: Ricmond, Oct 14/64.

FLAVA (Davidson), OESTLUNDIELLA
Moericke yellow pan water trap: Richmond, Aug 10/67.

FLAVA (Forbes), SIPHA
In flight: Oliver, no date (Richards 1972c).

FLOCCULOSA (Weed), PLOCAMAPHIS
Salix sp: Prospect Lake, Apr 16/57; Terrace, Jul 26/60 (Richards 1966b).

FORBESI (Richards), AMPHOROPHORA
Rubus spectabilis: Lulu Island, Jun 2 58.

FORBESI Weed, APHIS
Fragaria bracteata: Manning Park, May 25/59.
Fragaria chiloensis var *ananassa:* Vancouver, Jun 16/58, Jun 17/58, Oct 22/58.

FORNACULA Hottes, CINARA
Moericke yellow pan water trap: Chilliwack, Jun 4/65.

FRAGAEFOLII (Cockerell), CHAETOSIPHON
Fragaria chiloensis var *ananassa:* Abbotsford, Jul 15/58; Bradner, Apr 29/57; Brentwood, Aug 17 59; Chilliwack, Oct 13/58; Lulu Island, Aug 21/59, Sep 20/56; Saanich, May 30/55, Jun 5/59, Aug 21/59; Vancouver, Mar 18/58, Apr

17/59, May 5/59, May 21/59; Vancouver (UBC), Jun 16 59; Victoria, May 30 57.
Fragaria glauca: Williams Lake, Aug 4 /56.
Fragaria virginiana: Britannia Beach, Jul 9 65.
Potentilla anserina: Sea Island, Jul 14/59, Jul 23/58; Victoria, Aug 4/58.
Rosa sp: Quesnel, Aug 6/58; Terrace, Jul 9/60 (Richards 1963c).

FRAGARIAE (Walker), MACROSIPHUM
Cinna latifolia: Vancouver, May 25/58.
Gramineae: Vancouver, May 19/58.
Hordeum vulgare: Vancouver, Jun 19/58, Jul 18/56.
Rubus idaeus: Vancouver, Dec 1/59.
Rubus laciniatus: Richmond, Apr 23/71.
Rubus thyrsanthus: Vancouver, May 23/57.
Sisymbrium officinale: Vancouver (UBC), Jul 13/65.

FREQUENS (Walker), HOLCAPHIS
Moericke yellow pan water trap: Richmond, Jun 28/64, Jul 2/64.

GERANII Gillette & Palmer, AMPHOROPHORA
Geranium viscosissimum: Williams Lake, Aug 4/58.

GILLETTEI (Hottes), ESSIGELLA
Pinus ponderosa: Hat Creek, Aug 25/58.

GILLETTEI Davidson, EUCERAPHIS
Alnus rubra: Vancouver, Jul 13/65.
Alnus sp: Revelstoke National Park, Jul 25/67.

GRAMINUM (Rondani), SCHIZAPHIS
Moericke yellow pan water trap: Chilliwack, Jun 18/65, Jul 23/65; Richmond, Jul 4/64, Aug 13/64.

GRAVICORNIS (Patch), THECABIUS
Populus trichocarpa: Victoria, Aug 2/65.

HELIANTHI Monell, APHIS
Helianthus annuus: Kamloops, Aug 26/57.
Helianthus sp: Vancouver, Sep 24/58.

HELICHRYSI (Kaltenbach), BRACHYCAUDUS
Antirrhinum majus: Vancouver, Jun 6/59.
Capsella bursa-pastoris: Richmond, Apr 7/64.
Matricaria matricariodes: Vancouver, Apr 26/67.
Philadelphus gordonianus: Vancouver, May 22/57, May 28/61.
Prunus domestica: Lulu Island, May 23/57; Vancouver, May 6/58.
Senecio vulgaris: Lulu Island, Apr 7/64; Vancouver May 12/58.
Tagetes tenuiflora var *pumila:* Vancouver, Jun 23/67.
Trifolium pratense: Vancouver, Jul 25/56.
Vaccinium corymbosum: Vancouver, May 23/58.

HERACLELLA Davis, APHIS
Heracleum lanatum: Vancouver, Jun 22/66.
Pastinaca sativa: Victoria, Aug 12/53.
Sium suave: Williams Lake, Aug 7/58.

HIPPOPHAES (Walker), CAPITOPHORUS
Polygonum persicaria: Vancouver, Aug 29/57.

HORNI (Börner), CAPITOPHORUS
Moericke yellow pan water trap: Richmond, June 21/64, Jul 6/64.

HUMULI (Schrank), PHORODON
Humulus lupulus: Quesnel, Aug 7/67; Sardis, May 23/58, Jun 5/58.
Prunus cerasifera var *pissardi:* Victoria, Aug 2/65.
Prunus japonica: New Westminster, Jun 14/61.

IDAEI van der Goot, APHIS
Rubus idaeus: Vancouver, May 16/60, Jun 3/68, Jun 30/60, Jul 31/52, Sep 7/51; Vancouver (UBC), Apr 18/58.
Rubus loganobaccus: Vancouver, Jun 3/68.

INSERTUM Walker, RHOPALOSIPHUM
Malus pumila: Vancouver, Oct 18/57.

JUGLANDICOLA (Kaltenbach), CHROMAPHIS
Juglans sp: Agassiz, Jul 14/24; Creston, Aug 14 58; (Richards 1960a).

JUGLANDIS (Goeze), CALAPHIS
Juglans regia: Richmond, Jul 25/69.
Moericke yellow pan water trap: Chilliwack, Jul 30/67.

KIOWANEPHUM (Hottes), MACROSIPHUM
Zygadenus sp: Kamloops, Jun 27/37.

KONOI Takahashi, CAVARIELLA
Apium graveolens: Vancouver, Aug 6/57, Oct 8/57.
Salix lasiandra: Vancouver, Jun 9/65.

KURDJMOVI Mordvilko, SIPHA
Agropyron repens: Agassiz, Sep 13/56.
Agropyron sp: Creston, Aug 14/58.
Gramineae: Vancouver, Sep 26/57.

LACTUCAE (Linnaeus), HYPEROMYZUS
Lactuca pulchella: Creston, Sep 16 / 58.
Sonchus arvensis: Richmond, Jul 8 / 58; Vancouver (UBC), Jan 7 / 64.
Sonchus asper: Saanich, Aug 21 / 59; Vancouver (UBC), Aug 19 / 65.
Sonchus oleraceus: Vancouver, Jul 16 / 56.
Sonchus sp: Creston, Sep 15 / 58; Victoria, Jul 1 / 56.

LAMBERSI MacGillivray, MASONAPHIS
Rhododendron sp: North Vancouver, Jul 6 / 69.

LANIGERUM (Hausmann), ERIOSOMA
Malus pumila: Erickson, Oct 28 / 58; Vancouver, May 23 / 58, Aug 17 / 66, Nov 19 / 57.

LATYSIPHON (Davidson), RHOPALOSIPHONINUS
Solanum tuberosum: Ladner, Apr 17 / 63.

LONGICAUDA Richards, ASPIDAPHIS
Spiraea sp: Terrace, Aug 27 / 60 (Richards 1963b).
Moericke yellow pan water trap: Chilliwack, Jun 28 / 65, Jul 13 / 65.

LUGENTIS Williams, APHIS
Senecio jacobaea: Abbotsford, Jun 29 / 62; Vancouver, Mar 12 / 58, Jun 23 / 70.

LYROPICTUS (Kessler), PERIPHYLLUS
Acer macrophyllum: Vancouver, May 29 / 57.
Acer platanoides: Vancouver, May 14 / 60, Jun 30 / 60.
Acer sp: Chilliwack, May 28 / 59.

LYTHRI (Schrank), MYZUS
Prunus emarginata: Vancouver, Jun 15 / 64.

MACROSIPHUM (Wilson), ACYRTHOSIPHON
Viburnum trilobum: Quesnel, Aug 6 / 58.

MACROSTACHYAE (Essig), CHAITOPHORUS
Salix spp: (Richards 1972c).

MAIDIS (Fitch), RHOPALOSIPHUM
Moericke yellow pan water trap: Richmond, Sep 14 / 64.

MALVAE ROGERSII (Theobald), ACYRTHOSIPHON
Fragaria sp: Saanich, Jun 5 / 59; Vancouver (UBC), May 5 / 59.

MAXIMA (Mason), MASONAPHIS
Rubus parviflorus: Vancouver, May 24 / 56, Jun 9 / 58, Jun 9 / 67, Jun 29 / 67, Jul 7 / 67, Jul 21 / 67; Vancouver (UBC), Mar 31 / 66; Victoria, May 30 / 57.

MEDISPINOSA (Gillette & Palmer), CINARA
Pinus contorta: Burns Lake, Jun 11 / 56.

MILLEFOLII (DeGeer), MACROSIPHONIELLA
Chrysanthemum leucanthemum: Agassiz, Jul 7 / 66.

MORRISONI (Swain), MASONAPHIS
Moericke yellow pan water trap: Richmond, Jul 18 / 64.

MURRAYANAE (Gillette & Palmer), CINARA
Pinus contorta: Burns Lake, Jun 11 / 56.

NASTURTII Kaltenbach, APHIS
Moericke yellow pan water trap: Richmond, Jul 17 / 64, Aug 19 / 64, Aug 20 / 64.

NEGLECTUS Hottes & Frison, CHAITOPHORUS
Populus spp: (Richards 1972c).

NEGUNDINIS (Thomas), PERIPHYLLUS
Acer negundo: Soda Creek, Jun 16 / 57.

NEOMEXICANA (Cockerell), APHIS
Ribes lacustre: Quesnel, Aug 6 / 58; Vancouver, Jun 27 / 56.

NIGRAE Oestlund, CHAITOPHORUS
Salix spp: (Richards 1972c).

NIGROTUBERCULATUS Olive, DACTYNOTUS
Solidago canadensis: Abbotsford, Aug 13 / 65; Richmond, Aug 10 / 65.

NEPHRELEPIDUS Davis, IDIOPTERUS
Polypodiaceae: Vancouver, Apr 19 / 50.

NERVATA (Gillette), WAHLGRENIELLA
Arbutus menziesii: Vancouver, Mar 15 / 61.
Pieris japonica: Vancouver, May 5 / 67, May 23 / 67, Jun 15 / 67.
Rosa sp: Soda Creek, Aug 4 / 58.

NODULUS Richards, HOLCAPHIS
Gramineae: Summerland, Sep 6 / 55 (Richards 1959).

NORTONII Maxson, PEMPHIGUS
Moericke yellow pan water trap: Richmond, Jul 6 / 64, Jul 21 / 64.

NYMPHAEAE (Linnaeus) RHOPALOSIPHUM
Caltha sp: Vancouver, Aug 28 / 57.
Nuphar sp: (Richards 1960c).
Nymphaea sp: Vancouver, Jul 30 / 57, Aug, 28 / 57.

Prunus persica: (Richards 1960c); Vancouver, Sep 19 / 56.

OCCIDENTALIS (Davidson), CINARA
Abies balsamea: Unknown location in B.C., Oct 4 / 25.

OCCULTA Richards, MYZOCALLIS
Quercus rubra: Vancouver, Jul 13 / 59 (Richards 1965, 1968d).

ORNATUS Laing, MYZUS
Aubrieta deltoidea: Victoria, Apr 4 / 58.
Fragaria sp: Vancouver, Jan 3 / 61, Feb 7 / 57, Apr 17 / 59, May 18 / 61.
Fragaria vesca: Vancouver, Mar 2 / 58.
Fuchsia magellanica: Victoria, Aug 2 / 65.
Fuchsia sp: Vancouver, Feb 26 / 69.
Gladiolus sp: Vancouver, Apr 20 / 69.
Helianthemum nummularium: Vancouver, Jun 28 / 63.
Hypochaeris radicata: Vancouver (UBC), Jan 7 / 64 (in greenhouse).
Lamium amplexicaule: Vancouver (UBC), Apr 26 / 67.
Petroselinum crispum: Vancouver, May 18 / 58.
Primula sp: Burnaby, May 23 / 70.
Ranunculus sp: Vancouver (UBC), Jan 7 / 64.
Senecio vulgaris: Vancouver, May 12 / 58.
Viola tricolor: Vancouver, Mar 4 / 57, Jun 6 / 67, Jul 9 / 58.

OSMARONIAE (Wilson), MACROSIPHUM
Osmaronia cerasiformis: Victoria, Aug 2 / 65.

PADI (Linnaeus), RHOPALOSIPHUM
Avena sativa: Vancouver (UBC), May 29 / 58, Aug 20 / 57.
Cinna latifolia: Vancouver, May 25 / 58.
Gramineae: Vancouver (UBC), Feb 12 / 60.
Hordeum vulgare: Vancouver, Sep 30 / 66, Dec 20 / 60 (in greenhouse).
Secale cereale: Creston, Apr 22 / 59; Vancouver (UBC), May 9 / 58, May 8 / 59; Victoria, Apr 7 / 58.
Triticum aestivum: Creston, Oct 2 / 57; Vancouver (UBC), May 9 / 58, May 14 / 58.

PADIFORMIS Richards, RHOPALOSIPHUM
Poa sp: Terrace, Aug 2 / 60 (Richards 1962).

PALLIDUS Hille Ris Lambers, HYPEROMYZUS
Sonchus arvensis: Ladner, Aug 8 / 56.

PARVIFLORI Hill, AMPHOROPHORA
Rubus parviflorus: Vancouver, May 16 / 67, Jun 9 / 67, Jul 21 / 67.
Rubus thyrsanthus: Vancouver, Jun 8 / 67.

PARVIFOLII Richards, MACROSIPHUM
Vaccinium parvifolium: Campbell River, Jul 22 / 65 (Richards 1967d).

PASTINACAE (Linnaeus), CAVARIELLA
Heracleum maximum: Vancouver, Jun 14 / 65.

PERGANDEI (Wilson), CINARA
Moericke yellow pan water trap: Chilliwack, Jun 9 / 67.

PERSICAE (Sulzer), MYZUS
Brassica campestris: Lulu Ilsnad, Apr 7 / 64.
Brassica oleracea var *capitata:* Oliver, Jun 3 / 56.
Brassica sp: Agassiz, Jul 12 / 58, Jul 16 / 62.
Chrysanthemum morifolium: Vancouver, Jan 25 / 61, Oct 15 / 57.
Convolvulus arvensis: Victoria, Aug 2 / 65.
Cuscuta sp: Vancouver, May 25 / 71.
Daucus carota: Cloverdale, Nov 25 / 64.
Dianthus caryophyllus: Vancouver, Jun 6 / 63.
Fragaria sp: Abbotsford, Aug 1 / 58.
Fragaria vesca: Vancouver, Sep 25 / 64.
Hibiscus sp: Vancouver, Nov 12 / 70.
Matricaria matricarioides: Lulu Island, Apr 7 / 64.
Medicago sativa: Vancouver, Nov 20 / 72, Nov 22 / 72 (in greenhouse).
Philadelphus gordonianus: Vancouver (UBC), May 28 / 59, Jul / 56.
Polygonum convolvulus: Vancouver, Aug / 58.
Prunus persica: Summerland, May 28 / 58.
Senecio vulgaris: Vancouver, May 12 / 58.
Sisymbrium sp: Vancouver (UBC), Jul 13 / 65.
Solanum nigrum: Creston, Aug/58.
Solanum tuberosum: Boundary Bay, May 2 / 70; Courtenay, Aug 18 / 61; Pemberton, Sep 8 / 67; Quesnel, Aug 7 / 67; Richmond, Jul 23 57; Vancouver, Mar 25 / 58.
Stellaria media: Vancouver, Oct 3 / 67.
Ranunculus acris: Victoria, Aug 2 / 65.
Ranunculus sp: Abbotsford, Jul 19 / 65.
Raphanus raphanistrum: Lulu Island, Apr 7 / 64.
Rheum rhaponticum: Vancouver, Jul 20 / 65.
Rosa sp: Rykerts, Aug 25 / 58.
Tulipa gesneriana: Vancouver, Mar 10 / 58.
Viola tricolor: Vancouver, Jun 6 / 67.
Yucca smalliana: Vancouver, Jul 25 / 63.

PILOSUM Buckton, PTEROCOMMA
Salix sp: Vancouver, Oct 23 / 48.

PINEA (Mordvilko), CINARA
Pinus sylvestris: Abbotsford, May 3 / 68.

PINETI (Fabricius), SCHIZOLACHNUS
Pinus sylvestris: Abbotsford, May 3 / 68.

PISUM (Harris), ACYRTHOSIPHON
Cytisus scoparius: Vancouver, Jun 4 / 57.
Fragaria sp: Saanich, Jul 6 / 59.
Medicago sativa: Canyon, Jul 56; Creston, May 8 / 57, May 9 / 57, Jul / 58, Aug 13 / 58; Erickson, Jun / 58; Kamloops, Apr 30 / 72; Lister, Jun 5 / 57; Soda Creek, Aug 15 / 50, Aug 15 / 58; Vancouver, Mar 26 / 58.
Melilotus alba: Summerland, Jul 29 / 69.
Melilotus sp: Creston, Aug 13 / 58.
Trifolium sp: Cache Creek, Jul 13 / 65.

PLANTAGINEA (Passerini), DYSAPHIS
Malus sp: Vancouver, Sep 19 / 56.
Malus sylvestris: Creston, Jun 25 / 59; Vancouver, May 15 / 56, May 22 / 57.

PLATANI (Kaltenbach), TINOCALLIS
Ulmus americana: Victoria, May 20 / 28 (Richards 1965, 1967a).

PLATANOIDES (Schrank), DREPANOSIPHUM
Acer glabrum: Summerland, Sep 3 / 65.
Acer macrophyllum: Vancouver (UBC), May 5 / 66, May 6 / 65, May 7 / 66.
Acer negundo: Vancouver, May 14 / 43.
Acer sp: Vancouver, Aug 8 / 56.

POAE (Gillette), RHOPALOMYZUS
Gramineae: Vancouver, Sep 26 / 57.
Poa annua: Vancouver, Oct 25 / 61.

POMI DeGeer , APHIS
Chaenomeles japonica: Vancouver, Jun 3 / 58, Jul 20 / 58.
Cotoneaster henryana: Vancouver, Aug 3 / 58.
Cotoneaster sp: Vancouver, Aug 27 / 65.
Crataegus sp: Creston, Sep 16 / 58; Vancouver, Jul 3 / 61.
Malus coronaria: Vancouver, Jul 13 / 56.
Malus sp: Vancouver, May 9 / 56, Jun 27 / 69, Sep 19 / 56.
Malus sylvestris: Creston, Jun 8 / 59; Erickson, Oct 28 / 58; Vancouver, May 23 / 58, Jun 13 / 56, Jul 13 / 56, Aug 8 / 56, Aug 17 / 66, Sep 1 / 57, Oct 31 / 56.
Prunus persica: Vancouver, Sep 19 / 56.
Pyrus communis: Vancouver, Jun 6 / 57.

POPULICOLA (Thomas), CHAITOPHORUS
Populus sp: Creston, Aug 24 58.
Populus tremuloides: Williams Lake, Aug 4 / 58.

POPULIFOLIAE (Fitch), PTEROCOMMA
In flight: Burns Lake, Jun 2 / 56.

POPULIFOLII (Essig), CHAITOPHORUS
Populus trichocarpa: Summerland, Jul 28 / 69.

POPULIMONILIS (Riley), THECABIUS
Populus trichocarpa: Quesnel, Jul 27 / 48; Summerland, Jul 9 / 69.

POPULIRAMULORUM Riley, PEMPHIGUS
Moericke yellow pan water trap: Richmond, Jun 21 / 64, Jun 24 / 64, Jul 2 / 64, Jul 6 / 64, Jul 11 / 64, Jul 18 / 64.

POPULIVENAE Fitch, PEMPHIGUS
Chenopodium album: Agassiz, Jul 12 / 56.
Lactuca sativa: Agassiz, Sep 27 / 56; Vancouver, Aug 18 / 70, Oct 10 / 51.
Rumex acetosella: Lulu Island, May 20 / 60.

POTENTILLAE (Walker), CHAETOSIPHON
Potentilla anserina: Saanich, Aug 20 / 59; Sea Island, Jul 23 / 58.

PRUNI (Geoffroy),

PRUNI (Geoffroy), HYALOPTERUS
Phragmites communis: Westham Island, Jul 31 / 64.
Prunus sp: Oliver, Jun 3 / 56.

PSEUDOHEDERAE Theobald, APHIS
Hedera helix: Vancouver, Jul 18 / 57.

PSEUDOTAXIFOLIAE Palmer, CINARA
Pseudotsuga menziesii: Agassiz, Aug 3 / 33.

PTERICOLENS Patch, MACROSIPHUM
Polystichum munitum: Vancouver, Apr 8 / 64, Apr 29 / 58.

PTERINIGRUM Richards, AULACORTHUM
Pieris japonica: Vancouver, Jun 15 / 67.
Vaccinium sp: Terrace, Jul 18 / 60 (Richards 1972b).

PUNCTIPENNIS Zetterstedt, EUCERAPHIS
Alnus rubra: Vancouver (UBC), Oct 4 / 60.
Betula pendula: Vancouver (UBC), Apr 9 / 61, Apr 13 / 61, Apr 27 / 61, Oct 30 / 60.
Betula sp: Vancouver, May 4 / 67, Jul 7 / 70.

PUSTULATUS Hille Ris Lambers, CHAITOPHORUS
Salix sp: (Richards 1972c).

QUADRITUBERCULATA (Kaltenbach), BETULAPHIS
Betula sp: Chilliwack, Apr (Glendenning 1926); Terrace, Jul 12/60 (Richards 1961a); Vancouver, Oct. 3/60.

RHAMNI Clarke, MACROSIPHUM
Rhamnus purshiana: North Vancouver, Jul 15/65.

RIBIS (Linnaeus), CRYPTOMYZUS
Galeopsis tetrahit: Goldstream, Aug 20/59.
Ribes grossularia: Soda Creek, Jun 15/56.
Ribes sativum: Agassiz, Jul 12/56.
Ribes sp: Soda Creek, Jun 15/56.

RIBIS NIGRI (Mosley), NASONOVIA
Lactuca sp: Vancouver, Aug 18/57.
Lapsana communis: Vancouver, Jun 21/61.

RICHARDSI MacGillivray, MASONAPHIS
Moericke yellow pan water trap: Vancouver (UBC), Jul 4/66.

RIEHMI (Borner), THERIOAPHIS
Medicago sativa: Lister, Aug 25/58; Williams Lake, Aug 20/60 (Richards 1965).
Melilotus alba: Creston Flats, Jun 6/57.

ROBINIAE (Gillette), APPENDISETA
Robinia sp: Trail, Jul 21/59 (Richards 1965).
Moericke yellow pan water trap: Chilliwack, Aug 2/67, Aug 16/67.

ROBINSONI Richards, KAKIMIA
Delphinium cultorum: Kamloops, Jun 14/60.

ROSAE (Linnaeus), MACROSIPHUM
Ilex aquifolium: Saanich, Jul 6/59.
Rosa rugosa: Vancouver, Jun 27/58.
Rose sp: South Burnaby, Oct 17/67; Vancouver, Jan 6/58, Mar 31/38, Apr 8/58; Victoria, Apr 4/58.

ROSSI Hottes & Frison, AMPHOROPHORA
Geum macrophyllum: Vancouver, Jun 9/67.

RUBI (Kaltenbach), AMPHOROPHORA
Rubus idaeus: Agassiz, Apr 26/57, Jul 16/67; Burnaby, Jul 5/59.
Rubus occidentalis: Vancouver, May 1/56.

RUBITOXICA (Knowlton), AMPHOROPHORA
Rubs vitifolius: Vancouver, May 28/58; Victoria, May 31/57.

RUMEXICOLENS (Patch), BRACHYCAUDUS
Rumex acetosella: Lulu Island, Jul 6/66; Vancouver, Sep 9/65.

RUMICIS Linnaeus, APHIS
Rumex crispus: Kelowna, Jun 8/57; Vancouver, Jun 24/66.

RUSSELLAE Hille Ris Lambers, DACTYNOTUS
Moericke yellow pan water trap: Richmond, Jul 27/64, Sep 7/64, Sep 26 64; Vancouver, Jun 17/66, Jul 15/66./

SALICICORNII Richards, MACROSIPHUM
Salicornia europea: Queen Charlotte City, Aug 9/60 (Richards 1963a).

SALICIS (Linnaeus), PTEROCOMMA
Salix scouleriana: Agassiz, Aug 21/23.
Salix sp: Oliver, Jul 19/65; Summit Lake, Jun 26/59, Jul 15/59 (Richards 1967c).
In flight: Creston, May 8/67.

SALIGNUS (Gmelin), TUBEROLACHNUS
Salix sp: Victoria, Dec 11/63.

SAMBUCIFOLIAE Fitch, APHIS
Sambucus racemosa: Vancouver, May 24/56, May 25/60, May 29/56, Jun 18/52.

SANBORNI Gillette, MACROSIPHONIELLA
Chrysanthemum morifolium: Vancouver, Aug 28/61, Oct 23/61, Nov 26/58.

SCABROSUM Richards, AULACORTHUM
Rubus spectabilis: Queen Charlotte City, Aug 9/60 (Richards 1927b).

SCLEROSA Richards, ROEPKEA
Crataegus douglasii: Lumby, Jul 11/65 (Richards 1969b).
Crataegus sp: Victoria, Apr 17/58 (Richards 1969b).

SEDI Kaltenbach, APHIS
Sedum anglicum: Vancouver, Jun 30/60.

SENSORIATA (Gillette & Palmer), ROEPKEA
Amelanchier spp and *Trifolium pratense:* (Richards 1969b).

SETOSA (Kaltenbach), CTENOCALLIS
Cytisus scoparius: Mission, Jul 29/57.

SIPHUNCULATA Richards, PLACOAPHIS
In flight: Creston, Jun 6/55.
Unknown host: Bowser, May 28/55 (Richards 1961b).

SMITHIAE (Monell), PTEROCOMMA
Populus trichocarpa: Summerland, Sep 19/69.
Salix babylonica: North Vancouver, Aug.

24 / 66.
Salix fragilis: Vancouver, Oct. 2 / 58.
Salix lasiandra: Agassiz, May 14 / 21 (Richards 1967c).

SOLANI (Kaltenbach), AULACORTHUM
Apium graveolens: Vancouver, Nov 11 / 56.
Aquilegia sp: Vancouver, Jun 12 / 64.
Aucuba japonica: Vancouver, Mar 9 / 64, May 22 67.
Capsella bursa-pastoris: Richmond, Apr 7 / 64.
Erodium circutarium: Vancouver (UBC), Apr 26 / 67.
Fragaria chiloensis var *ananassa:* Abbotsford, Mar 17 / 58, Jul 15 / 58; Agassiz, May 5 / 57; Saanich, Apr 20 / 59; Vancouver, Apr 2 / 58, Apr 8 / 58.
Fragaria vesca: Vancouver, Mar 2 / 58, Nov 13 / 57, Nov 20 / 56.
Gramineae: Vancouver, Jun 21 / 61.
Helleborus niger: Vancouver, May 23 / 58.
Ilex aquifolium: Vancouver, May 1 / 58.
Matricaria matricariodes: Vancouver, Apr 26 / 67.
Mentha arvensis var *canadensis:* Vancouver, May 11 / 67.
Paulownia imperialis: Vancouver, Apr 30 / 58.
Philadelphus gordonianus: Vancouver, May 28 / 61, Jul 3 / 57.
Polygonum cuspidatum: North Vancouver, Jul 3 / 63.
Primula sp: Burnaby, May 23 / 70; Vancouver, Jan 18 / 58.
Ranunculus acris: Victoria, Aug 2 / 65.
Solanum tuberosum: Bella Coola, Sep 29 / 67; Quesnel, Aug 7 / 67.
Tulipa gesneriana: Richmond, May 17 / 67; Vancouver, May 24 / 58.

SONCHI (Linnaeus), DACTYNOTUS
Sonchus asper: Vancouver, Aug 19 / 65.

SPENCERI Richards, IZIPHYA
Unknown host: Chilcotin, Jun 9 / 29 (Richards 1958).

SPIRAEA (MacGillivray), MASONAPHIS
Philadelphus gordonianus: Vancouver, May 22 / 57.

SPLENDENS (Gillette & Palmer), CINARA
Moericke yellow pan water trap: Richmond, Jun 17 / 67; Vancouver (UBC), Jun 20 / 66.

STANLEYI (Wilson), MACROSIPHUM
Sambucus racemosa: North Vancouver, Jul 15 / 65; Vancouver, Jun 9 / 67.

STAPHYLEAE (Koch), RHOPALOSIPHONINUS
Tulipa gesneriana: New Westminster, Nov 20 / 59; Vancouver, May 24 / 58.

SYMPHORICARPI (Thomas), APHTHARGELIA
Symphoricarpos albus: Soda Creek, Jun 16 / 57; Vancouver, Jul 29 / 65; Williams Lake, Jun 15 / 56.

TANACETARIA (Kaltenbach), MACROSIPHONIELLA
Tanacetum vulgare: Cloverdale, Jun 16 / 56, Jun 26 / 58; Milner, Aug 2 / 58; Vancouver, Jun 27 / 56.

TARAXACI (Kaltenbach), DACTYNOTUS
Taraxacum officinale: Burnaby, Jul 9 / 63.

TESTUDINACEA (Fernie), PERIPHYLLUS
Acer circinatum: Vancouver, Jun 27 / 56.
Acer macrophyllum: Lulu Island, May 12 / 70; Vancouver, May 6 / 65, May 19 / 66, May 29 / 57, May 30 / 56, Jul 9 / 65; Vancouver (UBC), Apr 5 / 66, Apr 26 / 66, May 5 / 66; Victoria, Jun 7 / 67.
Acer palmatum: Vancouver, May 4 / 64, Jun 27 / 56.
Acer platanoides: Vancouver, May 14 / 58.

TETRARHODUS (Walker), CHAETOSIPHON
Rosa rugosa: Vancouver, Jun 27 / 58, Sep 19 / 56.
Rosa spp: Oliver, May 24 / 59; Terrace, Jul 9 / 60 (Richards 1963c).

TILIAE (Linnaeus), EUCALLIPTERUS
Tilia sp: Agassiz, Aug 7 / 21, Sep 9 / 21; Vancouver, May 17 / 49.

TORTICAUDA (Gillette), BIPERSONA
Cirsium vulgare: Kamloops, Sep 15 / 54.

TULIPAE (Boyer de Fonscolombe), DYSAPHIS
Tulipa gesneriana: New Westminster, Nov 20 / 59.

UMBELLA Richards, IZIPHYA
Carex spp: (Richards 1968c, 1971).

UMBELLATARUM (Koch), CAVARIELLA
Moericke yellow pan water trap: Chilliwack, Jul 12 / 67, Aug 8 / 67.

ULMIFOLII (Monell), TINOCALLIS
Ulmus spp: Agassiz, Jul 7 / 24; Trail, Jul

21/59 (Richards 1965).
Moericke yellow pan water trap: Chilliwack, Aug 3/67, Aug 15/67.

ULMISACCULI (Patch), COLOPHA
Gramineae: Duncan, Apr 7/64.

VARIABILIS Richards, BORNERINA
Alnus crispa spp *sinuata:* Vancouver (UBC), May 12/61.

Alnus spp: Terrace, Jul 10/60 (Richards 1961a).

VERRUCOSA (Gillette), ALLAPHIS
Carex spp: (Richards 1971).

VIMINALIS Monell, CHAITOPHORUS
Salix spp: Creston, Aug 13/58; Summerland, Jul 30/69.

WALSHII (Monell), MYZOCALLIS
Quercus borealis: Vancouver, Jun 19/59, Jul 13/59.
Quercus rubra: Vancouver, Oct 7/60.

XYLOSTEI (DeGeer), PROCIPHILUS
Viburnum trilobum: Quesnel, Jul 10/49.

YAGASOGAE (Hottes), MACROSIPHUM
Smilacina stellata: Manning Park, Aug 3/58.

YOHOENSIS (Bradley), ROEPKEA
Sorbus scopulina: (Richards 1969b).

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THE APHIDS (HOMOPTERA:APHIDIDAE) OF BRITISH COLUMBIA. 2. A HOST PLANT CATALOGUE[1]

A. R. FORBES AND B. D. FRAZER
Research Station, Agriculture Canada
Vancouver 8, British Columbia

ABSTRACT

A host plant catalogue is presented for 189 species of aphids collected in British Columbia.

INTRODUCTION

This paper presents a host plant catalogue for most of the aphids recorded in the basic list of the aphids of British Columbia (Forbes, Frazer, & MacCarthy 1973). Only aphids actually colonizing on hosts are included. Stray alate aphids and species taken only in traps are not included. The list will be of particular use to economic entomologists wishing to know the aphids which occur on crops and ornamentals and to entomologists studying vector transmission of plant virus diseases whenever they must know all the potential vectors that occur on a crop.

The plant hosts are listed alphabetically by genus and species. The aphids colonizing each host are given alphabetically by genus and species. A cross index of common names is included.

CATALOGUE OF HOST PLANTS

Abies balsamea — Balsam Fir
Cinara curvipes
Cinara occidentalis

Abies grandis — Grand Fir
Mindarus abietinus

Abies sp — Fir
Cinara abieticola

Acacia, False — see **Robinia**

Acer circinatum — Vine Maple
Periphyllus californiensis
Periphyllus testudinacea

Acer glabrum — (Rocky) Mountain Maple
Drepanosiphum platanoides
Periphyllus brevispinosus

Acer macrophyllum — Broadleaf Maple
Drepanosiphum platanoides
Periphyllus lyropictus
Periphyllus testudinacea

Acer negundo — Box-Elder
Drepanosiphum platanoides
Periphyllus negundinis

Acer palmatum — Japanese Maple
Periphyllus testudinacea

[1]Contribution No. 285, Research Station, 6660 N.W. Marine Dr., Vancouver 8, British Columbia.

Acer platanoides — Norway Maple
Periphyllus lyropictus
Periphyllus testudinacea

Acer sp — Maple
Drepanosiphum platanoides
Periphyllus californiensis
Periphyllus lyropictus

Adam's Needle — see **Yucca**
African Marigold — see **Tagetes**
African Violet — see **Saintpaulia**

Agropyron repens — Couch Grass
Sipha kurdjmovi

Agropyron sp — Wheat Grass
Macrosiphum avenae
Sipha kurdjmovi

Alder — see **Alnus**
Alder, Red — see **Alnus**
Alder, Sitka — see **Alnus**
Alfalfa — see **Medicago**

Allium schoenoprasum — Chives
Myzus ascalonicus

Alnus crispa ssp **sinuata** — Sitka Alder
Börnerina variabilis

Alnus rubra — Red Alder
Euceraphis gillettei
Euceraphis punctipennis
Pterocallis alni

Alnus sp — Alder
Börnerina variabilis
Euceraphis gillettei
Pterocallis alni

Amelanchier sp — Saskatoon Berry
Prociphilus corrugatans
Roepkea sensoriata

American Elm — see **Ulmus**

Amsinckia intermedia — Fiddle-Neck
Pleotrichophorus amsinckii

Anethum graveolens — Dill
Cavariella aegopodii

Annual Sowthistle — see **Sonchus**

Antirrhinum majus — Snapdragon
Brachycaudus helichrysi

Apium graveolens — Celery
Aulacorthum solani
Cavariella konoi

Apple	see **Malus**
Apple, Common	see **Malus**
Aquilegia sp	Columbine
Aulacorthum solani	
Kakimia essigi	
Arbutus	see**Arbutus**
Arbutus menziesii	Arbutus, Madrone
Wahlgreniella nervata	
Artemisia tridentata	Sagebrush
Aphis canae	
Macrosiphum coweni	
Aspen, Tremling	see **Populus**
Aster	see **Aster**
Aster sp	Aster
Dactynotus ambrosiae	
Aubrieta	see **Aubrieta**
Aubrieta deltoidea	Aubrieta
Myzus ascalonicus	
Myzus ornatus	
Aucuba, Japanese	see **Aucuba**
Aucuba japonica	Japanese Aucuba
Aulacorthum solani	
Myzus ascalonicus	
Avena sativa	Oat
Macrosiphum avenae	
Metopolophium dirhodum	
Rhopalosiphum padi	
Avens, Large-Leaved	see **Geum**
Balsam Fir	see **Abies**
Balsam Poplar	see **Populus**
Barberry, Japanese	see **Berberis**
Barley	see **Hordeum**
Beech, European	see **Fagus**
Beet, Sugar	see **Beta**
Berberis thunbergii	Japanese Barberry
Liosomaphis berberidis	
Berry, Saskatoon	see **Amelanchier**
Beta vulgaris	Sugar Beet
Aphis fabae	
Betula occidentalis	Western Birch
Cepegillettea betulifoliae	
Betula papyrifera	Paper Birch
Calaphis betulicola	
Betula pendula	Weeping Birch
Euceraphis punctipennis	
Betula sp	Birch
Betulaphis quadrituberculata	
Calaphis betulicola	
Euceraphis punctipennis	
Bindweed	see **Polygonum**
Bindweed, Dwarf	see **Convolvulus**
Birch	see **Betula**
Birch, Paper	see **Betula**
Birch, Weeping	see **Betula**
Birch, Western	see **Betula**
Bird Cherry	see **Osmaronia**
Bird Rape	see **Brassica**
Bittercress	see **Cardamine**
Blackberry, Cut-Leaved	see **Rubus**
Blackberry, Himalaya	see **Rubus**
Blackberry, Trailing	see **Rubus**
Blackcap Raspberry	see **Rubus**
Black Cottonwood	see **Populus**
Black Twin-Berry	see **Lonicera**
Bleeding Heart	see **Dicentra**
Blueberry	see **Vaccinium**
Blueberry, Highbush	see **Vaccinium**
Blueleaf Strawberry	see **Fragaria**
Blue Lettuce	see **Lactuca**
Blue Spruce	see **Picea**
Box-Elder	see **Acer**
Brassica campestris	Bird Rape
Hyadaphis erysimi	
Myzus persicae	
Brassica napobrassica	Swede Turnip, Rutabaga
Brevicoryne brassicae	
Brassica oleracea var **capitata**	Cabbage
Brevicoryne brassicae	
Myzus persicae	
Brassica oleracea var **gemmifera**	Brussels Sprouts
Brevicoryne brassicae	
Macrosiphum euphorbiae	
Brassica sp	Mustard
Myzus persicae	
Brittle Willow	see **Salix**
Broad Bean	see **Vicia**
Broadleaf Maple	see **Acer**
Broom, Dwarf,	see **Cytisus**
Broom, Scotch	see **Cytisus**
Broom, Spanish	see **Spartium**
Brussels Sprouts	see **Brassica**
Bull Thistle	see **Cirsium**
Buttercup	see **Ranunculus**
Buttercup, Tall	see **Ranunculus**
Cabbage	see **Brassica**
Caltha sp	Marsh Marigold
Rhopalosiphum nymphaeae	
Canada Mint	see **Mentha**
Canada Thislte	see **Cirsium**
Capsella bursa-pastoris	Shepherd's Purse
Aphis fabae	
Aulacorthum solani	
Brachycaudus helichrysi	
Myzus ascalonicus	
Cardamine oligosperma	Bittercress
Myzus ascalonicus	
Carex spp	Sedge
Allaphis verrucosa	
Iziphya umbella	
Trichocallis cyperi	
Carnation	see **Dianthus**

Carpinus betulus European Hornbeam
Myzocallis carpini

Carrot see **Daucus**
Cascara see **Rhamnus**
Castanea sp Chestnut
Myzocallis castanicola

Cat's Ear, Spotted see **Hypochoeris**
Ceanothus sanguineus Snowbrush
Aphis ceanothi

Celery see **Apium**
Chaenomeles japonica Japanese Quince
Ahis pomi

Charlock see **Rhaphanus**
Chenopodium album Lamb's Quarters
Brachycolus atriplicis
Pemphigus populivenae

Chenopodium glaucum Goosefoot
Aphis fabae

Cherry see **Prunus**
Cherry, Bird see **Osmaronia**
Cherry, Dwarf Flowering see **Prunus**
Cherry Plum see **Prunus**
Cherry, Sweet see **Prunus**
Cherry, Wild see **Prunus**
Chestnut see **Castanea**
Chickweed see **Stellaria**
Chickweed, Common see **Stellaria**
Chives see **Allium**
Christmas Rose see **Helleborus**
Chrysanthemum see **Chrysanthemum**

Chrysanthemum leucanthemum Ox-Eye Daisy
Macrosiphoniella millefolii

Chrysanthemum morifolium Chrysanthemum
Macrosiphoniella sanborni
Macrosiphum euphorbiae
Myzus persicae

Cicely, Sweet see **Osmorhiza**
Cinna latifolia Indian Reed Grass
Macrosiphum fragariae
Rhopalosiphum padi

Cirsium arvense Canada Thistle
Aphis fabae
Dactynotus cirsii
Macrosiphum euphorbiae

Cirsium brevistylum Indian Thistle
Capitophorus elaeagni
Dactynotus cirsii

Cirsium sp Thistle
Dactynotus cirsii

Cirsium undulatum Wavy-Leafed Thistle
Brachycaudus cardui

Cirsium vulgare Bull Thistle
Bipersona torticauda

Clover see **Trifolium**
Clover, Red see **Trifolium**
Clover, Sweet see **Melilotus**
Clover, White Sweet see **Melilotus**
Columbine see **Aquilegia**
Common Apple see **Malus**
Common Chickweed see **Stellaria**
Common Dandelion see **Taraxacum**
Common Groundsel see **Senecio**
Common Reed see **Phragmites**
Convolvulus arvensis Dwarf Bindweed
Myzus persicae

Corn see **Zea**

Cornus nuttallii Flowering Dogwood
Macrosiphum euphorbiae

Corylus avellana Hazelnut
Myzocallis coryli

Corylus sp Filbert
Myzocallis coryli

Cotoneaster see **Cotoneaster**

Cotoneaster henryana Henry's Cotoneaster
Aphis pomi

Cotoneaster, Henry's see **Cotoneaster**
Cotoneaster sp Cotoneaster
Aphis pomi

Cottonwood, Black see **Populus**
Couch Grass see **Agropyron**
Cow Parsnip see **Heracleum**
Crabapple, Wild Sweet see **Malus**
Crabapples, Ornamental and Table see **Malus**
Cranberry, Highbush see **Vaccinium**
Crataegus douglasii Douglas Hawthorn
Roepkea sclerosa

Crataegus spp Hawthorn
Aphis pomi
Metopolophium dirhodum
Rhopalosiphum fitchii
Roepkea crataegifoliae
Roepkea sclerosa

Croft Lily see **Lilium**
Curled Dock see **Rumex**
Currant see **Ribes**
Currant, Red see **Ribes**
Cuscuta sp Dodder
Myzus persicae

Cut-Leaved Blackberry see **Rubus**
Cytisus demissus Dwarf Broom
Aphis cytisorum

Cytisus scoparius Scotch Broom
Acyrthosiphon pisum
Ctenocallis setosa

Dactylis glomerata Orchard Grass
Hyalopteroides dactylidis

Daisy, Ox-Eye see **Chrysanthemum**
Dandelion, Common see **Taraxacum**

Daucus carota Carrot
Cavariella aegopodii
Myzus persicae

Delphinium cultorum Perennial Delphinium
Kakimia robinsoni

Delphinium, Perennial see **Delphinium**

Dianthus caryolphyllus Carnation
Myzus persicae

Dicentra formosa Bleeding Heart
Macrosiphum euphorbiae

Dill see **Anethum**
Dodder see **Cuscuta**
Dogwood, Flowering see **Cornus**
Douglas Fir see **Pseudotsuga**
Douglas Hawthorn see **Crataegus**
Doves-Foot Geranium see **Geranium**
Dwarf Bindweed see **Convolvulus**
Dwarf Broom see **Cytisus**
Dwarf Flowering Cherry see **Prunus**
Dwarf Marigold see **Tagetes**
Elder see **Sambucus**
Elder, Red-Fruited see **Sambucus**
Elm see **Ulmus**
Elm, American see **Ulmus**
English Holly see **Ilex**
English Ivy see **Hedera**
English Walnut see **Juglans**

Epilobium angustifolium Fireweed
Aphis corniella

Epilobium sp Fireweed
Aphis corniella
Macrosiphum euphorbiae

Erodium cicutarium Filaree, Storksbill
Aulacorthum solani
Myzus ascalonicus

Euonymus alatus Winged Spindle Tree
Aphis fabae

European Beech see **Fagus**
European Hornbeam see **Carpinus**
(European) Wild Wood Strawberry see **Fragaria**

Fagus sylvatica European Beech
Phyllaphis fagi

False Acacia see **Robinia**
Fern, Sword see **Polystichum**
Fiddle-Neck see **Amsinckia**
Filaree see **Erodium**
Filbert see **Corylus**
Fir see **Abies**
Fir, Balsam see **Abies**
Fir, Douglas see **Pseudotsuga**
Fir, Grand see **Abies**
Fireweed see **Epilobium**
Flowering Dogwood see **Cornus**

Fragaria bracteata Wild Strawberry
Aphis forbesi

Fragaria chiloensis var **ananassa** Strawberry
Aphis forbesi
Aulacorthum solani
Chaetosiphon fragaefolii
Macrosiphum euphorbiae
Myzus ascalonicus

Fragaria glauca Blueleaf Strawberry
Chaetosiphon fragaefolii

Fragaria spp Strawberries
Acyrthosiphon malvae rogersii
Acyrthosiphon pisum
Fimbriaphis fimbriata
Myzus ornatus
Myzus persicae

Fragaria vesca (European) Wild Wood Strawberry
Aulacorthum solani
Myzus ornatus
Myzus persicae

Fragaria virginiana Virginia Strawberry
Chaetosiphon fragaefolii

Fuchsia see **Fuchsia**

Fuchsia magellanica Peruvian Fuchsia
Myzus ornatus

Fuchsia, Peruvian see **Fuchsia**

Fuchsia sp Fuchsia
Myzus ornatus

Galeopsis tetrahit Hemp Nettle
Cryptomyzus ribis

Garden Lettuce see **Lactuca**
Garry Oak see **Quercus**

Gaultheria shallon Salal
Aulacorthum dorsatum

Geranium see **Pelargonium**
Geranium, Doves-Foot see **Geranium**

Geranium molle Doves-Foot Geranium
Myzus ascalonicus

Geranium, Sticky, see **Geranium**

Geranium viscosissimum Sticky Geranium
Amphorophora geranii
Macrosiphum aetheocornum

Geum macrophyllum Large-Leaved Avens
Amphororphora rossi
Macrosiphum euphorbiae
Myzus ascalonicus

Galdiolus see **Gladiolus**

Gladiolus hortulanus Gladiolus
Aphis fabae
Macrosiphum euphorbiae

Gladiolus sp Gladiolus
Myzus ornatus

Golden Chain see **Laburnum**
Golden-Rod see **Solidago**
Gooseberry see **Ribes**
Goosefoot see **Chenopodium**

Gramineae Grass Family
Aulacorthum solani
Colopha ulmisacculi
Holocaphis nodulus
Macrosiphum avenae
Macrosiphum fragariae
Rhopalomyzus poae
Rhopalosiphum padi
Sipha kurdjmovi
Sitomyzus columbiae

Grand Fir see **Abies**
Grass, Couch see **Agropyron**
Grass, Low Spear see **Poa**
Grass, Meadow see **Poa**
Grass, Orchard see **Dactylis**
Grass, Velvet see **Holcus**
Grass, Wheat see **Agropyron**
Grindelia stricta Gum Weed
Dactynotus erigeronensis

Groundsel, Common see **Senecio**
Gum Weed see **Grindelia**
Hawthorn see **Crataegus**
Hawthorn, Douglas see **Crataegus**
Hazelnut see **Corylus**
Hedera helix English Ivy
Aphis pseudohederae

Hedge Mustard see **Sisymbrium**

Helianthemum nummularium Rock Rose
Myzus ornatus

Helianthus annuus Sunflower
Aphis helianthi

Helianthus sp Sunflower
Aphis helianthi

Helleborus niger Christmas Rose
Aulacorthum solani

Hemp Nettle see **Galeopsis**
Henbit see **Lamium**
Henry's Cotoneaster see **Cotoneaster**

Heracleum maximum Cow Parsnip
Aphis heraclella
Cavariella pastinacae
Macrosiphum euphorbiae
Myzus ascalonicus

Hesperis matronalis Sweet Rocket
Myzus ascalonicus

Hibiscus see **Hibiscus**
Hibiscus sp Hibiscus
Myzus persicae

Highbush Blueberry see **Vaccinium**
Highbush Cranberry see **Viburnum**
Himalaya Blackberry see **Rubus**
Holcus lanatus Velvet Grass
Hyalopteroides dactylidis

Holly, English see **Ilex**
Holodiscus discolor Ocean Spray
Macrosiphum euphorbiae

Hop see **Humulus**
Hordeum vulgare Barley
Macrosiphum avenae
Macrosiphum fragariae
Metopolophium dirhodum
Rhopalosiphum padi

Hornbeam, European see **Carpinus**
Huckleberry, Red see **Vaccinium**
Humulus lupulus Hop
Phorodon humuli

Hybrid Roses see **Rosa**

Hypochoeris radicata Spotted Cat's Ear
Myzus ascalonicus
Myzus ornatus

Ilex aquifolium English Holly
Aphis fabae
Aulacorthum solani
Macrosiphum euphorbiae
Macrosiphum rosae

Indian Reed Grass see **Cinna**
Indian Thistle see **Cirsium**
Iris see **Iris**
Iris sp Iris
Aulacorthum circumflexus

Ivy, English see **Hedera**
Japanese Andromeda see **Pieris**
Japanese Aucuba see **Aucuba**
Japanese Barberry see **Berberis**
Japanese Knotweed see **Polygonum**
Japanese Maple see **Acer**
Japanese Quince see **Chaenomeles**
Juglans regia English Walnut
Calaphis juglandis
Chromaphis juglandicola

Knotweed, Japanese see **Polygonum**
Laburnum anagyroides Golden Chain
Aphis craccivora

Lactuca pulchella Blue Lettuce
Hyperomyzus lactucae
Macrosiphum euphorbiae

Lactuca sativa Garden Lettuce
Macrosiphum euphorbiae
Pemphigus populivenae

Lactuca sp Lettuce
Nasonovia ribis nigri

Lady's Thumb see **Polygonum**
Lamb's Quarters see **Chenopodium**
Lamium amplexicaule Henbit
Myzus ornatus

Lapsana communis Nipplewort
Nasonovia ribis nigri

Large-Leaved Avens see **Geum**
Leguminosae Pea Family
Roepkea crataegifoliae

Lettuce see **Lactuca**
Lettuce, Blue see **Lactuca**

Lettuce, Garden see **Lactuca**
Lilium longiflorum Croft Lily
Aulacorthum circumflexus
Lilium speciosum Showy Lily
Myzus ascalonicus
Lily, Croft see **Lilium**
Lily-Of-The-Valley, Wild see **Maianthemum**
Lily, Showy see **Lilium**
Linden see **Tilia**
Lodgepole Pine see **Pinus**
Loganberry see **Rubus**
Lonicera involucrata Black Twin-Berry
Masonaphis crystleae
Low Spear Grass see **Poa**
Lupine, Perennial see **Lupinus**
Lupinus sp Perennial Lupine
Macrosiphum albifrons
Lyall's Nettle see **Urtica**
Lycopersicum esculentum Tomato
Aphis fabae
Madrone see **Arbutus**
Maianthemum dilatatum Wild Lily-Of-The-Valley
Macrosiphum euphorbiae
Maize see **Zea**
Malus coronaria Wild Sweet Crabapple
Aphis pomi
Malus pumila Common Apple
Eriosoma lanigerum
Macrosiphum euphorbiae
Rhopalosiphum insertum
Roepkea bakeri
Malus spp Ornamental & Table Crabapples
Aphis pomi
Dysaphis plantaginea
Rhopalosiphum fitchii
Malus sylvestris Apple
Aphis pomi
Dysaphis plantaginea
Roepkea bakeri
Maple see **Acer**
Maple, Broadleaf see **Acer**
Maple, Japanese see **Acer**
Maple, Norway see **Acer**
Maple, (Rocky) Mountain see **Acer**
Maple, Vine see **Acer**
Marigold, African see **Tagetes**
Marigold, Dwarf see **Tagetes**
Marigold, Marsh see **Caltha**
Marsh Marigold see **Caltha**
Matricaria matricarioides Pineapple Weed
Aphis fabae
Aulacorthum solani
Brachycaudus helichrysi
Macrosiphum euphorbiae
Myzus persicae
Meadow Grass see **Poa**
Medicago sativa Alfalfa
Acyrthosiphon pisum
Macrosiphum euphorbiae
Myzus persicae
Therioaphis riehmi
Melilotus alba White Sweet Clover
Acyrthosiphon pisum
Macrosiphum euphorbiae
Therioaphis riehmi
Melilotus sp Sweet Clover
Acyrthosiphon pisum
Mentha arvensis var canadensis Canada Mint
Aulacorthum solani
Capitophorus elaeagni
Ovatus crataegarius
Mint, Canada see **Mentha**
Mock Orange see **Philadelphus**
Mountain Ash, Wild see **Sorbus**
Mustard see **Brassica**
Mustard, Hedge see **Sisymbrium**
Mustard, Tall Hedge see **Sisymbrium**
Nasturtium see **Tropaeolum**
Nettle, Hemp see **Galeopsis**
Netle, Lyall's see **Urtica**
Nightshade see **Solanum**
Nipplewort see **Lapsana**
Northern Red Oak see **Quercus**
Norway Maple see **Acer**
Nuphar sp Yellow Pond-Lily
Rhopalosiphum nymphaeae
Nymphaea sp Waterlily
Rhopalosiphum nymphaeae
Oak, Garry see **Quercus**
Oak, Northern Red see **Quercus**
Oak, Red see **Quercus**
Oat see **Avena**
Ocean Spray see **Holodiscus**
Oenanthe sarmentosa Water Parsley
Cavariella aegopodii
Orchard Grass see **Dactylis**
Ornamental and Table Crabapples see **Malus**
Osmaronia cerasiformis Bird Cherry
Macrosiphum osmaroniae
Osmorhiza chilensis Sweet Cicely
Myzus ascalonicus
Oxalis deppei Wood Sorrel
Aphis fabae
Ox-Eye Daisy see **Chrysanthemum**
Pacific Willow see **Salix**
Pansy see **Viola**
Paper Birch see **Betula**
Parsley see **Petroselinum**
Parsley, Water see **Oenanthe**
Parsnip see **Pastinaca**
Parsnip, Cow see **Heracleum**

Parsnip, Water — see **Sium**
Pastinaca sativa — Parsnip
Aphis heraclella

Paulownia — see **Paulownia**
Paulownia imperialis — Paulownia
Aulacorthum solani

Peach — see **Prunus**
Pear — see **Pyrus**
Pelargonium hortorum — Geranium
Aulacorthum circumflexus

Perennial Delphinium — see **Delphinium**
Perennial Lupine — see **Lupinus**
Perennial Sowthistle — see **Sonchus**
Peruvian Fuchsia — see **Fuchsia**
Petroselinum crispum — Parsley
Myzum ornatus

Philadelphus gordonianus — Mock Orange
Aphis fabae
Aulacorthum solani
Brachycaudus helichrysi
Macrosiphum euphorbiae
Masonaphis spiraeae
Myzus persicae

Phragmites communis — Common Reed
Hyalopterus pruni

Picea pungens — Blue Sprice
Cinara braggi
Cinara coloradensis
Cinara costata
Elatobium abietinum

Picea sitchensis — Sitka Spruce
Elatobium abietinum

Picea sp — Spruce
Elatobium abietinum

Pieris japonica — Japanese Andromeda
Aulacorthum pterinigrum
Wahlgreniella nervata

Pineapple Weed — see **Matricaria**
Pine, Lodgepole — see **Pinus**
Pine, Ponderosa — see **Pinus**
Pine, Scots — see **Pinus**
Pinus contorta — Lodgepole Pine
Cinara brevispinosa
Cinara medispinosa
Cinara murrayanae

Pinus ponderosa — Ponderosa Pine
Essigella gillettei

Pinus sylvestris — Scots Pine
Cinara pinea
Schizolachnus pineti

Plantago lanceolata — Ribgrass
Myzus ascalonicus

Plum — see **Prunus**
Poa annua — Low Spear Grass
Rhopalomyzus poae

Poa sp — Meadow Grass
Rhopalosiphum padiformis

Polygonum convolvulus — Bindweed
Myzus persicae

Polygonum cuspidatum — Japanese Knotweed
Aulacorthum solani

Polygonum persicaria — Lady's Thumb
Aphis fabae
Capitophorus hippophaes

Polypodiaceae — Fern Family
Idiopterus nephrelepidus

Polystichum munitum — Sword Fern
Macrosiphum ptericolens

Ponderosa Pine — see **Pinus**
Pond-Lily, Yellow — see **Nuphar**
Poplar — see **Populus**
Poplar, Balsam — see **Populus**
Populus balsamifera — Balsam Poplar
Pterocomma bicolor bicolor

Populus sp — Poplar
Chaitophorus delicatus
Chaitophorus neglectus
Chaitophorus populicola

Populus tremuloides — Trembling Aspen
Chaitophorus populicola

Populus trichocarpa — Black Cottonwood
Chaitophorus populifolii
Pterocomma bicolor bicolor
Pterocomma smithiae
Thecabius gravicornis
Thecabius populimonilis

Potato — see **Solanum**
Potentilla anserina — Silver Weed
Chaetosiphon fragaefolii
Chaetosiphon potentillae

Primrose — see **Primula**
Primula sp — Primrose
Aulacorthum circumflexus
Aulacorthum solani
Myzus ornatus

Prunus avium — Sweet Cherry
Myzus cerasi

Prunus cerasifera var pissardi — Cherry Plum
Phorodon humuli

Prunus domestica — Plum
Brachycaudus cardui
Brachycaudus helichrysi

Prunus emarginata — Wild Cherry
Myzus cerasi
Myzus lythri

Prunus japonica — Dwarf Flowering Cherry
Phorodon humuli

Prunus persica — Peach
Aphis pomi
Myzus persicae
Rhopalosiphum nymphaeae

Prunus sp — Cherry
Hyalopterus pruni

Pseudotsuga menziesii — Douglas Fir
Cinara pseudotaxifoliae

Pyrus communis — Pear
Aphis pomi

Quercus borealis — Northern Red Oak
Myzocallis walshii

Quercus garryana — Garry Oak
Thelaxes albipes
Thelaxes californica
Tuberculatus columbiae

Quercus rubra — Red Oak
Myzocallis occulta
Myzocallis walshii

Quince, Japanese — see **Chaenomeles**
Radish — see **Raphanus**
Ragwort, Tansy — see **Senecio**

Ranunculus acris — Tall Buttercup
Aulacorthum solani
Myzus persicae

Ranunculus sp — Buttercup
Aphis fabae
Myzus ornatus
Myzus persicae

Rape, Bird — see **Brassica**

Raphanus raphanistrum — Charlock
Myzus persicae

Raphanus sativus — Radish
Brevicoryne brassicae

Raspberry, Blackcap — see **Rubus**
Raspberry, Red — see **Rubus**
Red Alder — see **Alnus**
Red Clover — see **Trifolium**
Red Currant — see **Ribes**
Red-Fruited Elder — see **Sambucus**
Red Huckleberry — see **Vaccinium**
Red Oak — see **Quercus**
Red Raspberry — see **Rubus**
Reed, Common — see **Phragmites**
Reed Grass, Indian — see **Cinna**

Rhamnus purshiana — Cascara
Macrosiphum rhamni

Rheum rhaponticum — Rhubarb
Aphis fabae
Macrosiphum euphorbiae
Myzus persicae

Rhododendron — see **Rhododendron**

Rhdodendron sp — Rhododendron
Masonaphis lambersi

Rhubarb — see **Rheum**

Ribes grossularia — Gooseberry
Cryptomyzus ribis

Ribes lacustre — Swamp Gooseberry
Aphis neomexicana

Ribes sativum — Red Currant
Cryptomyzus ribis

Ribes sp — Currant
Cryptomyzus ribis

Ribgrass — see **Plantago**

Robinia sp — False Acacia
Appendiseta robiniae

Rock Rose — see **Helianthemum**
(Rocky) Mountain Maple — see **Acer**

Rosa rugosa — Rugose-Leaved Rose
Chaetosiphon tetrarhodus
Macrosiphum rosae
Metopolophium dirhodum

Rosa spp — Hybrid Roses
Aulacorthum clavicornis
Chaetosiphon fragaefolii
Chaetosiphon tetrarhodus
Macrosiphum euphorbiae
Macrosiphum rosae
Metopolophium dirhodum
Myzus persicae
Wahlgreniella nervata

Rose, Christmas — see **Helleborus**
Rose, Rock — see **Helianthemum**
Rose, Rugose-Leaved — see **Rosa**
Roses, Hybrid — see **Rosa**

Rubus idaeus — Red Raspberry
Amphorophora rubi
Aphis idaei
Macrosiphum euphorbiae
Macrosiphum fragariae

Rubus laciniatus — Cut-Leaved Blackberry
Macrosiphum fragariae

Rubus loganobaccus — Loganberry
Aphis idaei

Rubus occidentalis — Blackcap Raspberry
Amphorophora rubi

Rubus parviflorus — Thimbleberry
Amphorophora parviflori
Masonaphis davidsoni
Masonaphis maxima

Rubus spectabilis — Salmonberry
Amphorophora forbesi
Aulacorthum scabrosum

Rubus thyrsanthus — Himalaya Blackberry
Amphorophora parviflori
Macrosiphum fragariae

Rubus vitifolius — Trailing Blackberry
Amphorophora rubitoxica

Rugose-Leaved Rose — see **Rosa**

Rumex acetosella — Sheep Sorrel
Brachycaudus rumexicolens
Myzus ascalonicus
Pemphigus populivenae

Rumex crispus — Curled Dock
Aphis rumicis

Spruce see **Picea**
Spruce, Blue see **Picea**
Spruce, Sitka see **Picea**
Star-Flowered Solomon's Seal see **Smilacina**
Stellaria media Common Chickweed
Myzus persicae

Stellaria sp Chickweed
Myzus ascalonicus

Sticky Geranium see **Geranium**
Stonecrop see **Sedum**
Storksbill see **Erodium**
Strawberry see **Fragaria**
Strawberry, Blueleaf see **Fragaria**
Strawberry, (European) Wild Wood see **Fragaria**
Strawberry, Virginia see **Fragaria**
Strawberry, Wild see **Fragaria**
Strawberry, Wild Wood see **Fragaria**
Sugar Beet see **Beta**
Sunflower see **Helianthus**
Swamp Gooseberry see**Ribes**
Swede Turnip see **Brassica**
Sweet Cherry see **Prunus**
Sweet Cicely see ~~Osmorhiza~~
Sweet Clover see **Melilotus**
Sweet Rocket see **Hesperis**
Sword Fern see **Polystichum**
Symphoricarpos albus Snowberry
Aphthargelia symphoricarpi

Targetes erecta African Marigold
Macrosiphum euphorbiae

Tagetes tenuiflora var **pumila** Dwarf Marigold
Brachycaudus helichrysi

Tall Buttercup see **Ranunculus**
Tall Hedge Mustard see **Sisymbrium**
Tanacetum vulgare Tansy
Macrosiphoniella tanacetaria

Tansy see **Tanacetum**
Tansy Ragwort see **Senecio**
Taraxacum officinale Common Dandelion
Dactynotus taraxaci
Myzus ascalonicus

Thimbleberry see **Rubs**
Thistle see **Cirsium**
Thistle, Bull see **Cirsium**
Thistle, Canada see **Cirsium**
Thistle, Indian see **Cirsium**
Thistle, Wavy-Leafed see **Cirsium**
Tilia sp Linden
Eucallipterus tiliae

Tomato see **Lycopersicum**
Trailing Blackberry see **Rubus**
Trembling Aspen see **Populus**
Trifolium pratense Red Clover
Brachycaudus helichrysi
Roepkea sensoriata

Trifolium sp Clover
Acyrthosiphon pisum
Reopkea bakeri

Triticum aestivum Wheat
Macrosiphum avenae
Rhopalosiphum padi

Tropaeolum majus Nasturtium
Aphis fabae

Tulip see **Tulipa**
Tulipa gesneriana Tulip
Aulacorthum circumflexus
Aulacorthum solani
Dysaphis tulipae
Dysaphis tulipae
Macrosiphum euphorbiae
Myzus persicae
Rhopalosiphoninus staphyleae

Turnip, Swede see **Brassica**
Twin-Berry, Black see **Lonicera**
Ulmus americana American Elm
Tinocallis platani

Ulmus sp Elm
Eriosoma americanum
Tinocallis ulmifolii

Urtica lyallii Lyall's Nettle
Macrosiphum euphorbiae

Vaccinium corymbosum Highbush Blueberry
Brachycaudus helichrysi
Fimbriaphis fimbriata

Vaccinium parvifolium Red Huckleberry
Macrosiphum parvifolii

Vaccinium sp Blueberry
Aulacorthum pterinigrum
Fimbriaphis fimbriata

Velvet Grass see **Holcus**
Viburnum opulus Snowball
Ceruraphis eriophori

Viburnum trilobum Highbush Cranberry
Acyrthosiphon macrosiphum
Prociphilus xylostei

Vicia faba Broad Bean
Aphis fabae

Vine Maple see **Acer**
Viola tricolor Pansy
Aulacorthum circumflexus
Myzus ascalonicus
Myzus ornatus
Myzus persicae

Violet, African see **Saintpaulia**
Virginia Strawberry see **Fragaria**
Walnut, English see **Juglans**
Waterlily see **Nymphaea**
Water Parsley see **Oenanthe**
Water Parsnip see **Sium**
Wavy-Leafed Thistle see **Cirsium**

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A NOTE ON THE TAXONOMY OF THE PSYLLIDAE OF BRITISH COLUMBIA

I. D. HODKINSON[1]

Kitching (1971) recently published a key to the Psyllidae of British Columbia which contains a number of nomenclatorial and taxonomic errors. His key is based on the monographs of Crawford (1914) and Tuthill (1943) and more recent work has not been considered. The purpose of this note is to try to bring the nomenclature in line with modern usage.

Tuthill (1944) replaced the name *Psylla uncata* Tuthill by *Psylla hamata* Tuthill as the former was preoccupied by *Psylla uncata* Ferris & Klyver.

Arytaina spartiophila has only one basal metatarsal spine and would therefore not fall within the proposed definition of the Psyllinae (Kitching p. 38). Couplet 3 should be modified to read — Basal tarsal segment of hind legs with at least one black claw-like spine at tip. This will make the key valid for North American species but not for the world species.

[1]Environmental Sciences Centre (Kananaskis), University of Calgary, Calgary, Alberta.

Heslop-Harrison (1961) discussed the North American *Arytaina* in detail and established four new genera, three of which are relevant here. *Arytaina robusta* and *A. fuscipennis* are referable to the genus *Euglyptoneura* H-H., *A. ceanothi* to the genus *Ceanothia* H-H. and *A. pubescens* to the genus *Purshivora* H-H. This does not alter the validity of the key at the species level.

The American scheme of psyllid classification is based on that proposed by Crawford in 1914. Modern authors working outside North America (Vondracek 1957, Dobreanu & Manolache 1962, Loginova 1967) have since split certain of the genera recognised by Crawford and these divisions appear valid on both morphological and biological grounds. On the modern European classification system *Livia caricis* is referable to the genus *Diraphia* Waga and *Aphalara* sensu Crawford is split into *Aphalara* sensu stricta and *Craspedolepta* Enderlein on the basis of the form of the clypeus. A revision of the North American *Aphalara* is thus urgently required.

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Heslop-Harrison, G. 1961. The Arytainini of the subfamily Psyllinae, Hemiptera-Homoptera, family Psyllidae.-II. Ann. Mag. nat. Hist. (ser. 13) **3:** 417-439.

Kitching, R. L. 1971. The Psyllidae of British Columbia with a key to species. J. Entomol. Soc. Brit. Columbia **68:** 36-43.

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Tuthill. L. D. 1943. The psyllids of America north of Mexico (Psyllidae:Homoptera). Iowa St. Coll. J. Sci. **17:** 443-660.

Tuthill, L. D. 1944. Descriptions of some new North American Psyllidae with notes on others. J. Kansas ent. Soc. **17:** 1-6.

Vondracek, K. 1957. Mery Psylloidea. Fauna C.S.R. **9:** 431 pp.

Loginova (1972) (Commentat. Biol. Soc. Sic. Fenn. **47:** 1-37) has recently placed **Arytaina spartiophila** in a new genus **Arytainilla** Log.

Pendergast, C. 1971. *Introduction to Organic Gardening.* Nash Publishing, Los Angeles, 167 pp., $2.50 in Canada.

Null, G. and Staff. 1972. *How to Grow Food Organically.* Leisure Books, Inc., New York, 278 pp., 95c.

Tyler, H. 1972. *Organic Gardening Without Poisons.* Pocket Books (Simon & Schuster), New York, 224 pp., $1.50.

Rodale, Robert, *Ed.* 1971. *The Basic Book of Organic Gardening.* Ballantyne Books, Inc., New York, 377 pp., $1.25.

Harrison, J. B. 1972. *Good Food Naturally.* J. J. Douglas Ltd., West Vancouver, 116 pp., $3.95.

As one who struggled for years to grow food in pre-DDT days, with indifferent success, I have a sceptic's interest in the current outbreak of books on organic gardening. Listing this randomly chosen quintet of paperbacks in my own ascending order of merit was a temptation not to be resisted.

The first is well printed and bound, carelessly proofread and without illustrations, which might even have improved it; they could scarcely have harmed it. The book exemplifies everything that is half-baked about the organic food movement. This is a pity because the movement is a logical and healthy reaction to the hard sell of over-refined and over-processed convenience foods, to careless and excessive use of chemicals, and less logically, to mass-produced, farm-factory foods.

Much is made here of the Grand Plan of Nature. This is never laid out in so many words, but the phrase is repeated over and over. Insects and insecticides are covered in 5 pages which confirm the superficiality of the author's knowledge. Some samples: the insect world numbers in the millions of species; there are 60,000 different types of pesticides; "It is an established fact that insects will attack an unhealthy plant before they will attack a healthy, sound plant . . ." (the insects could easily be trapped if only they knew this established fact too); "insecticides . . . began killing large numbers of other animals including man himself. There are lakes and streams *throughout* our country which are *totally devoid* of *all* life because of these wonder powders. Hundreds of thousands of acres of farm and forest lands have been sprayed, and sprayed again, poisoning the lands and *all* of the life upon it." (P. 149. Emphasis added). This is poor stuff for a book published in 1971. The facts of pollution are bad enough without piling falsehood on exaggeration.

The author extrapolates from amateur gardening to commercial farming without, apparently, recognizing any difference in scale. His treatment of gardening consists mostly of sketchy instructions on how to make compost, rather than on how to grow fruits and vegetables, as stated on the cover. Nowhere does he suggest specific methods to reduce insect damage. The whole issue is quickly sidestepped by stating that there is an enormous number of ways, all of them easy and available through a short trip to the library. No bibliography is given.

The author has an irritating knack for the wrong word, e.g.: erosion will be stifled; Sir Howard (Sir Albert Howard) forcibly exclaimed his stand; scientists who regaled in their achievements; our youth formulating a significant number of people. The writing in general is an abrasive mixture of high-flown phrases, italics and colloquialisms. It includes some completely meaningless passages about which it is difficult to write soberly; for instance: (P. 97) "A soil that is rich in microscopic life, is rich in organic matter, and is a fertile soil. A soil that is rich in organic matter is naturally a soil that is rich in microscopic life. Nature works in ever-widening circles." In ever-narrowing ones too, apparently.

Only the most heady enthusiast could

seriously wade all the way through this dull inflated, inaccurate and repetitious potboiler. I finished it with a sense of relief.

The second book is somewhat more professionally written, but I seemed not to have changed books as I struggled through the deep verbal muskeg of scores of pages of maundering about nature's cycles. I suspect that authors such as these confine their reading to each other's books, which they paraphrase for themselves. Whole pages could be exchanged between them and no one would guess the difference.

At least some instructions are given here on how to grow plants. But the book appeals fairly directly also to food faddists. Thus the last 41 pp. are devoted to brief descriptions of the nutritive value of foods, from agar-agar, ale and almonds, through carob, caviar, cola nuts, crab meat, malt, mango, margarine and oysters to vinegar, walnut and yogurt; obviously not restricted to the simpler garden crops. This is preceded by 22 pp. of tables on the vitamins of ordinary foods and their content of vital elements. The authors subscribe to the theory of "plastic" vegetables, according to which "chemicalized" foods are at best non-nutritious and at worst, toxic. There is a special but undefined meaning for the word toxic; it appears to be a much more serious and dangerous condition than merely poisonous.

On chemical pesticides (6 pp.), the authors are still hung up on DDT, which is the only one named. It is stated to be firmly linked to cancer and capable of doubling the rate of human mutation (P. 57). Before the 1940's, farmers are said to have "used natural, traditional methods, including biological control." Farmers in the 1930's and earlier did indeed use pyrethrum and rotenone but they also used traditional compounds of iron, lead, mercury, phosphorus, copper, fluorine, thallium, and most common, effective, dangerous, and persistent of all, the biocide, arsenic. There were no others available.

A number of chapters have bibliographies which refer to books rather than to articles. Something went wrong with the already inadequate 2-page index. In twenty tries I could not find a page reference that was even close.

This is not true of the book by H. A. Tyler, which has a good index. The cover blurb states that the author is a professional gardener, trained in the natural sceinces. It comes through clearly that he works from personal experience and knows whereof he writes. There is a fair amount of padding: the type is large; the right margin is irregular as in typescript; full pages and even double pages are devoted to photos of subjects such as: earthworms, compost, soil, tilling processes, a few pests and useful animals, gardens in California, the author, a handsome old dog, doing his thing, and some drawings of birds, pests, equipment and bird boxes. Nevertheless, it is a book that might appeal to many gardeners. The instructions for growing are reasonably specific so that the book could serve as a reference. It is vastly superior to the two reviewed above.

The last chapter, on the wastage of manure from large feed lots and possible solutions to the problem, is excellent.

The Rodale name should indicate that the next book is written by pros, and that the information has stood the test of time. True enough, with a few reservations. The book is organized as follows: What is an organic gardener? (8 pp.), Secrets of the best organic gardeners (96 pp.), What to grow and how (210 pp.), Protection against the bugs (50 pp.), When to harvest (16 pp.), The organic way (22 pp.), an appendix containing addresses of distributors of natural fertilizers, etc. (3 in B.C.) and organic gardening clubs (1 in B.C.), a good glossary and an index. Mostly straightforward stuff.

The section on pest control is the weakest in the book. It includes about equal amounts of enthusiasm, good sense, anthropomorphism, faith, wishful thinking, and unanswered questions. The enthusiasm is pervasive; the good sense pops up now and then as in advocating the keeping of bantam hens in the garden, a very old technique; the anthropomorphism shows, among other places, in ladybugs feasting on scales, and various birds relishing, delighting, deriving great joy or satisfaction from pests; the faith and wishful thinking go together. Aphids are said to detest plans grown in organically rich soil—but the aphids do not agree, at least not those in my garden; woodpeckers are said to consume more than 50% of codling moth larvae in winter — perhaps so, but they are hopelessly ineffective as controls in western North America, according to J. A. Marshall; bird boxes are said to attract birds that will take care of all insect problems — but the disruptive and aggressive starlings and English sparrows are scarcely mentioned.

The unanswered questions are such as these: for bean beetle control some gardeners are said to have used a mixture of crushed turnips and corn oil (P. 266). But how? In what amounts? When been beetles are active surely turnips are mostly seedlings? "Hot pepper spray is an easy and certain control" for

root maggots (P. 271). How? As a repellant? On the soil? In the soil? Against adult flies? Denatured alcohol is the remedy for mealybugs on house plants. How? No method is given. A 3% oil spray is advised for mites. Not in summer, surely? Non-toxic sprays of "sour milk and salt mixtures" are said to be effective against cabbage maggots (P. 267). How does one get sour milk through a spray nozzle? What are the nontoxic but effective concentrations of salt? And where are they applied? The habit these authors have of skipping lightly over the nitty gritty details of pest control is disconcerting and contrasts with 210 pp. of meticulous instructions on exactly what to grow, precisely how and where.

A spurious air of veracity is given by some references to published scientific papers, such as those of plant pathologists who attempted to reduce transmission of certain viruses by treatment with juice from pepper plants; or the finding that sugar kills nematodes. We read that fungi are the enemy of nematodes (P. 241), but the fungi are unspecified; the impression given is any fungi. These findings are still several removes from garden application.

The text is based on material that has appeared in Organic Gardening Magazine, and so is written by nearly a dozen authors, including notably the editor. In sum the book is worthwhile and a good one to recommend to prospective organic gardeners who can hardly fail to find of lead of some kind if not a cure for most problems.

Although it is attractively printed, bound and illustrated, it is a pity that John Harrison's book is so expensive, for it is by far the best of this group in every respect. Harrison has a deft turn of phrase and his writing is direct, fresher and more personal than that of the hacks who grind out material they have "researched", or that of the dozen professional organic writers. The first chapter, in fact, is autobiographical and presents his personal philosophy.

Harrison's grasp of science and scientific method is weak, but there is nothing wrong with his understanding of the economics of food production, nor of his distinction between farming and gardening. He is the only one of these authors who appears to make any connection between the population problem and food mass-produced with chemical fertilizers. He seems to be the only one who has actually made a living by organic farming rather than by writing about it. He was helped in this by having settled close to a large and affluent centre of population where he could get the loyal clientele and carriage trade prices that his methods demanded.

Having long eschewed their use, Harrison appears to have little real knowledge of insecticides. He drags out tired arguments such as the one about insects acquiring resistance from sub-lethal doses, then needing stronger and stronger chemicals for control. None can question the logic of his argument that those who profit from chemicals should do the work of assaying them. In fact they do. But would Harrison really prefer that the chemical companies also make the final decisions on acceptance or rejection, use patterns and dosages. Somebody has to. Would he not prefer that these details be worked out by responsible public servants with no axe to grind? Only ten pages are given to Pests and Pesticides, so that the treatment is necessarily superficial.

The chapters on Planting and Growing, Harvesting and Storing, are clear, quite specific in their instructions, and well illustrated; they include five pages on cooking. The final chapter is a mixed bag of advice, much of which seems to belong in foregoing sections. The organization falls off, but it is possible to find references with a good 5-page index.

H. R. MacCarthy

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CONTROL OF THE PEAR LEAF BLISTER MITE AND THE PEAR RUST MITE (ACARINA: ERIOPHYIDAE) IN BRITISH COLUMBIA[1]

R. S. DOWNING AND T. K. MOILLIET
Research Station, Agriculture Canada
Summerland, British Columbia

ABSTRACT

Delayed dormant applications of endosulfan plus oil or ethion plus oil gave excellent control of both the pear leaf blister mite, **Eriophyes pyri** (Pgst.), and the pear rust mite, **Epitrimerus pyri** (Nal.) Lime sulphur as a dormant spray gave excellent control of the pear leaf blister mite but the delayed dormant application gave poor control. Both applications of lime sulphur gave good control of the pear rust mite.

Introduction

Lime sulphur as a dormant spray has been recommended for control of the pear leaf blister mite, *Eriophyes pyri* (Pgst.), for at least 60 years and has been quite effective if the spray was applied between the time the leaves start to drop in fall and before the buds start to swell in late winter. Many fruitgrowers are unable to apply sprays during this period due to snow cover, muddy orchard soil, lack of water for the sprayer or conflict with other orchard operations. Lime sulphur is becoming difficult to obtain and its cost has increased several fold during the last decade. Therefore, substitutes for the dormant application of lime sulphur are very desirable. Oil as a dormant or a delayed dormant spray has given good control of the blister mite in Oregon (Childs 1924) but has been less effective in British Columbia (Downing 1954). However, the combination of oil plus an organophosphate insecticide as a delayed dormant spray is recommended for control of the pear leaf blister mite in the State of Washington (Anonymous 1973). Endosulfan has been very effective against rust mites and when combined with oil has been useful against other pests. Comparisons between these sprays and dormant and delayed dormant applications of lime sulphur were made for the control of pear blister mite and pear rust mite, *Epitrimerus pyri* (Nal.), in British Columbia.

Methods

Two Bartlett pear orchards, two and three acres (0.8 and 1.2 hectare) in size with trees spaced 15 ft. by 15 ft. (4.57 m) and infested with the pear rust mite and pear leaf blister mite were selected for the experiment. The orchards were divided into 20-to-50-tree plots so that there were 5 plots per treatment. Sprays were applied with a 1969 Turbo-Mist sprayer set to deliver 60 gallons per acre (673 litres per hectare). The dormant sprays were applied March 5 and the delayed dormant sprays March 16, 1973. On May 1, 1973, samples of all the leaves from 36 spurs per plot were examined and the numbers of blistered leaves were recorded. In mid-August, 1000 leaves and 100 fruit from each plot were examined and the numbers of blistered leaves and russeted fruit were recorded.

Results and Discussion

The effects of dormant and delayed dormant treatments are summarized in Table 1 for the pear leaf blister and in Table 2 for the pear rust mite.

[1]Contribution No. 382, Research Station, Summerland.

Table I. Average percentages of Bartlett pear leaves blistered by the pear leaf blister mite after application of sprays.

Insecticide	Amount per acre	Amount per hectare	Time of application	Blistered leaves, % May 1973	Aug. 1973
Lime sulphur	15 gal.	168 1	Dormant	0	0
Lime sulphur	15 gal.	168 1	Delayed dormant	19	9
Endosulfan 50% W.P. Dormant oil	3 lb. 6 gal.	3.35 kg 67.2 1	Delayed dormant	0	0
Ethion 25% W.P. Dormant oil	8 lb. 6 gal.	8.96 kg 67.2 1	Delayed dormant	0	0
Check - no treatment				52	10

An outstanding result of this investigation was the excellent control of both the pear leaf blister mite and the pear rust mite given by the delayed dormant application of endosulfan plus oil or ethion plus oil. Lime sulphur as a dormant spray also gave excellent control of the pear leaf blister mite but the delayed dormant application gave poor control. Oviposition by overwintered blister mites had already commenced by the delayed dormant period and eggs laid prior to this apparently were not killed by lime sulphur. Against the pear rust mite, however, both applications of lime sulphur gave good control.

The delayed dormant sprays of oil plus endosulfan or oil plus ethion could help with the control of pests other than the blister and the rust mite. In the State of Washington and some other fruit growing areas, endosulfan plus oil is recommended for control of pear psylla, *Psylla pyricola* Forester. Ethion plus oil provides good control of some aphids. Both endosulfan plus oil and ethion plus oil help in the control of the European red mite, *Panonychus ulmi* (Koch), and the San Jose scale, *Quadraspidiotus perniciosus* (Comstock).

Table 2. Average percentage of Bartlett pear fruit russeted by the pear leaf rust mite after application of sprays.

Insecticide	Amount per acre	Time of application	Percent fruit russeted at harvest, Aug. 14, 1973
Lime sulphur	15 gal.	Dormant	2
Lime sulphur	15 gal.	Delayed dormant	3
Endosulfan 50% W.P. Dormant oil	3 lb. 6 gal.	Delayed dormant	0
Ethion 25% W.P. Dormant oil	8 lb. 6 gal.	Delayed dormant	0
Check - no treatment			40

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INSECTS AND MITES ASSOCIATED WITH FRESH CATTLE DUNG IN THE SOUTHERN INTERIOR OF BRITISH COLUMBIA

ANGUS MACQUEEN[1] AND BRYAN P. BEIRNE

Pestology Centre, Department of Biological Sciences,
Simon Fraser University, Burnaby, British Columbia V5A 1S6

ABSTRACT

Sixty-seven species or genera of insects were found associated with fresh cattle dung in the Southern Interior of British Columbia. Three species of mites were associated with two of the insect species. About one-half of the species of Coleoptera and Diptera concerned are known or thought to be introduced.

Introduction

Cattle dung does not decompose quickly in the semi-arid rangelands of the southern Interior of British Columbia. Dried dung pads usually remain on the soil for long periods. While the dung is fresh it is a food and rearing medium for the larvae of two dipterous pests of cattle: the horn fly and the face fly. Later, the dried pads clutter rangeland and pastures as a store of undecomposed plant nutrients.

Insects have been the most successful group in exploiting animal dung in various ways, and they range from the truly coprophagous forms such as muscoid flies and dung beetles (Scarabaeidae) to the predators and parasites that prey upon many of the coprophages. It is possible and desirable to manipulate the insect fauna of dung through the careful introduction of certain insect species. These will suppress noxious species such as the horn fly (Macqueen and Beirne in prep.) and will help to bury the dung (Macqueen and Beirne in prep.).

Methods

During the summer of 1970 dung insects were collected by hand in the Kamloops and Summerland areas of British Columbia. In 1971 and 1972, as an off-shoot of field investigations into the production of horn fly from naturally-dropped cattle dung pads (Macqueen and Beirne in prep.) on irrigated pasture, insects were bred from pads that had been exposed in the field for 24 hours and then were removed to individual emergence cages in a greenhouse.

Results

A large number of dung insects emerged from the samples collected in the field. A few species in addition to these were taken during other field work. Table 1 lists these insects. The collection is not exhaustive because this investigation was mainly concerned with certain types of insects that breed in the dung, namely:

—prevalent coprophagous species that might be important basic units in food chains within the pads and which, along with the horn fly, are probably inhabitants only of fresh dung;

—predaceous and parasitic insects that prey on the coprophagous species;

—species that manipulate the dung mass (Scarabaeidae: Aphodiinae and Scarabaeinae).

Some species that actually breed in dung may have been omitted because of their erratic occurrence or low numbers, but it is highly unlikely that any moderately prevalent dung-breeding species are not included.

[1]Present address: Division of Entomology, SCIRO, Private Bag No. 3, Indooroopilly, Queensland 4068, Australia.

Table. 1. Insects associated with fresh cattle dung on range and irrigated pastures at Kamloops, B.C., 1970-72.

SPECIES	AUTHORITY*	ORIGIN
ORDER COLEOPTERA		
Histeridae		
Hister abbreviatus F.	3	Native?
Saprinus lubricus Lec.	3	Native?
Saprinus oregonensis Hatch	3	Native
Margarinotus umbrosus Casey	3	Native
Hydrophilidae		
Cercyon spp.	11	
Sphaeridium bipustulatum F.	11	Exotic
Sphaeridium lunatum F.	11	Exotic
Sphaeridium scarabaeoides L.	11	Exotic
Scarabaeidae		
Boreocanthon simplex (Lec.)	2	Native
Onthophagus nuchicornis (L.)	2	Exotic
Aphodius fossor (L.)	2	Exotic
Aphodius fimetaruis (L.)	2	Exotic
Aphodius congregatus Mann.	1	Native
Aphodius distinctus (Muell.)	1	Exotic
Aphodius granarius (L.)	1	Exotic
Aphodius haemorrhoidalis (L.)	1	Exotic
Aphodius pectoralis Lec.	1	Native
Aphodius tenellus Say	1	Native
Aphodius vittatus Say	1	Native
Staphylinidae		
Aleochara bimaculata Grav.	3	Exotic
Hyponygrus obsidianus Melsh.	3	Native?
Ontholestes cingulatus Grav.	3	Native
Philonthus cruentatus Gmelin	3	Exotic
Philonthus debilis Grav.	3	Exotic
Philonthus fuscipennis Mann.	3	Exotic
Philonthus rectangulus Sharp	3	Exotic
****Philonthus sanguinolentus** Grav.	3	Exotic
Platystethus americanus Erich.	3	Native
Tachinus nigricornis Mann.	3	Native
ORDER DIPTERA		
Ceratopogonidae		
Forcipomyia brevipennis (Macquart)	5	?
Stratiomyidae		
Sargus cuprarius (L.)	10	Exotic
Microchrysa flavicornis (Meig.)	10	Native
Otitidae		
Physiphora demandata (F.)	6	?

**First record of this species in Canada.

SPECIES	AUTHORITY*	ORIGIN
Sphaeroceridae		
Copromyza atra (Meig.)	13	?
Leptocera spp.	13	
Sepsidae		
Sepsis neocynipsea Mel. & Spul.	6	?
Saltella sphondylii (Schr.)	6	?
Anthomyiidae		
Calythea micropteryx (Thoms.)	6	Native
Scatophagidae		
Scatophaga furcata (Say)	14	Native
Scatophaga stercoraria (L.)	14	Exotic?
Muscidae		
Haematobia irritans (L.)	14	Exotic
Helina duplicata (Meig.)	14	Exotic
Hydrotaea armipes (Fall.)	14	Exotic?
Morellia micans (Macquart)	14	Native
Myospila meditabunda (F.)	14	Exotic
Musca autumnalis DeGeer	14	Exotic
Musca domestica (L.)	16	Exotic?
Orthellia caesarion (Meig.)	14	Exotic?
Pyrellia cyanicolor (Zett.)	14	Native?
Pegomya spp.	6	
Calliphoridae		
Eucalliphora lilaea (Walk.)	4	Native
Phormia regina (Meig.)	4	Exotic?
Sarcophagidae		
Ravinia l'herminieri (Rob.-Desv.)	4	Native
Ravinia planifrons (Ald.)	12	Native
Ravinia querula (Walk.)	4	Native
ORDER HYMENOPTERA		
Braconidae		
Aphaereta pallipes (Say)	9	Native
Trichopria (subg. **Phaenopria**): 2 spp.	8	
Asobara n. sp.	9	
Cynipidae		
Kleidotoma fossa Kieff.	15	Native?
Figitidae		
Figites n. sp.?	15	
Xyalophora quinquelineata (Say)	15	Native?
Melanips ? **bilineatus** (Kieff.)	15	
Pteromalidae		
Muscidifurax raptor Gir. & Saund.	15	?
Muscidifurax zaraptor Kogan & Legner	15	Native
Spalangia haematobiae Ashm.	15	Native
ORDER ACARINA		
Pyemotidae (Pygmephorini)		
Pediculaster mesembrinae (R. Can.) (associated with **Haematobia irritans** (L.))	7	

SPECIES	AUTHORITY*	ORIGIN
Parasitidae		
Parasitus sp. (associated with **Aphodius fossor** (L.)	7	
Macrochelidae		
Macrocheles glaber group: sp. near **Perglaber** Fil. & Peg. (associated with **Aphodius fossor** (L.))	7	

*Insects were identified by (1) H. F. Howden, Department of Biology, Carleton University, Ottawa; and the following members of the Taxonomy Section, Entomology Research Institute, Agriculture Canada, Ottawa: (2) E. C. Becker; (3) J. M. Campbell; (4) B. Cooper; (5) L. Foster; (6) J. F. McAlpine; (7) E. E. Lindquist; (8) L. Masner; (9) W. R. Mason; (10) B. V. Peterson; (11) R. de Ruette; (12) G. E. Shewell; (13) H. J. Teskey; (14) J. R. Vockeroth; and (15) C. M. Yoshimoto; and also (16) the senior author.

Where possible, the geographical origin of each species was determined, either from the literature or from the authority responsible for the identification. Species are designated as exotic if there is documentation that they were introduced into North America since the arrival of the Europeans and native if it is considered that they have a natural Nearctic distribution. For many species that currently have a Holarctic distribution, it is impossible to determine an area of origin with certainty. These have a question mark (?) in the column designating their origin in Table 1. If there is some, but not definitive, evidence for a certain origin of these Holarctic species, the question mark appears after the possible origin.

Discussion

Coffey (1966) and Poorbaugh, Anderson, and Burger (1968) gave extensive lists of flies and other insects associated with cattle dung in southeastern Washington and in California, respectively. These authors collected flies that were attracted to dung, as well as those reared from it. It is likely that some of the species they mention are present at Kamloops but are not listed here because they do not breed in the dung.

Nearly half of the species in Table 1 were introduced accidentally from Europe or Asia: thirteen of the species of Coleoptera listed are known as probably native whereas 15 are known as probably exotic; the corresponding figures for Diptera are 9 and 10 and for the Hymenoptera 5 and 0. Lindroth (1957) recognized the European origin of a number of insects associated with cattle dung on the east coast of North America. Most have spread across the continent to the west coast (Poorbaugh *et al.* 1968), although there have been occasional separate introductions into the West as in the case of the dung beetle, *Onthophagus nuchicornis* (L.) (Howden and Cartwright 1963; Howden 1966). The British Columbian dung fauna is essentially very similar to that listed for California by Poorbaugh *et al.* (1968). Comparison of the west coast fauna with that associated with cattle dung in Indiana (Sanders and Dobson 1966) and Texas (Blume 1970) shows differences mainly in the Coleoptera.

The general spread of cattle throughout much of North America has afforded a means for establishment of many introduced bucoprophilous species, i.e., those attracted to cattle dung, and may have enabled

some indigenous species to expand their original ranges. The result is that there is now a diverse dung fauna in the Southern Interior. The original coprophilous fauna in the area may have consisted of relatively few species. Many of the introduced insects that undoubtedly coexisted in Europe are now reunited under somewhat different circumstances. Some are known predators and parasites of the horn fly and the face fly. It is fortunate that the same imperfect quarantine precautions which permitted those pest flies to enter North America has also tempered their economic impact by also allowing the introduction of some of their natural enemies.

Acknowledgements

We wish to thank Dr. Howden, Department of Biology, Carleton University, Ottawa, and the members of the Taxonomy Section, ERI, Canada Agriculture, Ottawa, for making the identifications and providing information on certain insect origins.

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LARVAL HEAD-CAPSULE WIDTHS OF *DENDROCTONUS RUFIPENNIS* (KIRBY) (COLEOPTERA: SCOLYTIDAE)

P. M. Hall and E. D. A. Dyer

Department of the Environment, Canadian Forestry Service
Pacific Forest Research Centre, Victoria, British Columbia

ABSTRACT

Widths of larval head capsules of **D. rufipennis** (Kirby) were measured and analysed. The frequency distribution had four distinct modes corresponding to the four larval instars. The change in mean head-capsule widths between instars showed agreement with Dyar's Rule.

Résumé

Les auteurs mesurèrent la largeur des capsules formant les têtes des larves de **D. rufipennis** (Kirby). La distribution de fréquences se divisa en quatre modes distincts qui correspondaient aux quatre stades larvaires. Le changement d'une largeur moyenne à l'autre de chaque stade concordait avec la règle de Dyar.

Introduction

Spruce beetles, *Dendroctonus rufipennis* (Kirby), normally have a 2-year life cycle (Massey and Wygant, 1954); however, due to variations in environmental conditions, 1- and 3-year cycles have been reported (Knight, 1961). Variation in length of the life cycle is due partly to the effects of different temperatures on the rate of larval development. In studies of the population biology of the spruce beetle, determination of larval instars is required to understand how far development has progressed toward maturity. Prebble (1933), Walters and McMullen (1956) and Reid (1962) have shown that larval instars of scolytids can be separated and identified by the head-capsule width, which remains constant for the duration of each instar. The presence of four instars has been cited for several other species in the genus *Dendroctonus*: *D. brevicomis* Lec. (Miller and Keen, 1960), *D. frontalis* Zimm. (Wood, 1963), *D. simplex* Lec. (Prebble, 1933) and *D. ponderosae* Hopk. (Reid, 1962). The current study was conducted to determine the number of instars of the spruce beetle and the corresponding mean head-capsule widths and their variability.

Methods

Spruce beetle larvae were collected from spruce (*Picea glauca* (Moench) Voss) in the Naver forest near Prince George, British Columbia, and preserved in 70% ethanol. Other larvae were reared in spruce logs at a constant temperature of 68°F (20°C) to obtain additional early-instar larvae for measurement. A dissecting microscope with ocular micrometer was used to measure the greatest width of each head capsule to the nearest micron.

The head capsule widths were grouped into 0.02 mm classes for the construction of a histogram (Fig. 1). This histogram had four distinct peaks corresponding to four instars. Because of the overlap of curves, the class marks with the four highest frequencies were taken as the mean head-capsule widths of the larval instars and the standard deviations were calculated as a function of the mean and range. The mean and range accurately represent the instar values because of the large number of samples and symmetry of the individual curves.

Results and Discussion

This study shows that there are four distinct larval instars in *Dendroctonus rufipennis* (Kirby) and that

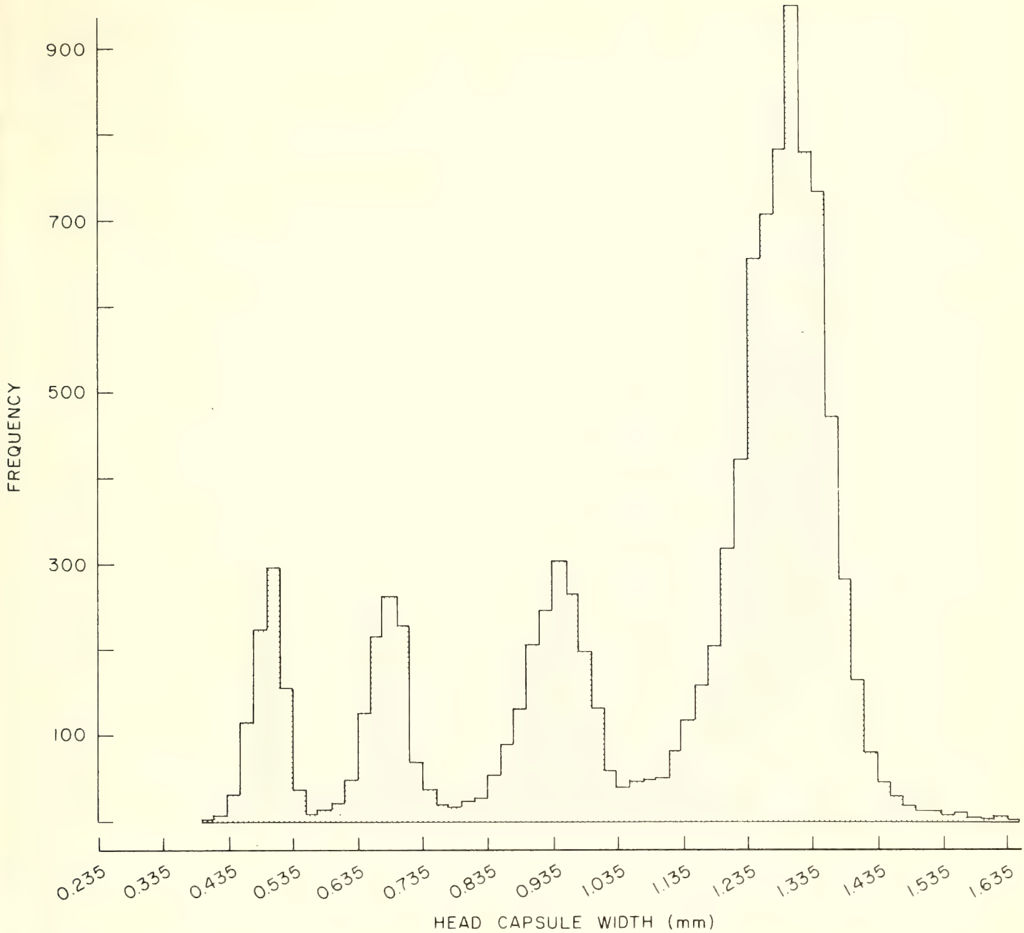

Fig. 1. Histogram of larval head-capsule widths of **Dendroctonus rufipennis** (Kirby)

the developmental stage of larvae can be established by measurement of head-capsule widths. The mean head-capsule widths of the four instars were significantly ($p = 0.05$) different from each other (Table I). Also, the

Table I. **Dendroctonus rufipennis** (Kirby) larval head-capsule widths

Instar	Sample Size	Range (mm)	Mean (mm)	Std. Dev. (mm)
I	878	0.396-0.615	0.505 ± 0.001[1]	0.022
II	1066	0.516-0.855	0.685 ± 0.002	0.034
III	1766	0.716-1.175	0.945 ± 0.002	0.046
IV	7218	0.956-1.655	1.305 ± 0.002	0.071

1/ 95% confidence belt

mean head-capsule widths of successive instars increase linearly with an average growth factor of 1.37x, which is in good agreement with Dyar's Rule (Dyar, 1890). For the purposes of instar identification, the range of each instar may be taken as falling between the lowest intermodal frequencies.

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BOOK REVIEW

Bionomics and Embryology of the Inland Floodwater Mosquito Aedes vexans. W. R. Horsfall, H. W. Fowler, Jr., L. M. Moretti and J. R. Larsen. University of Illinois Press, 1973.

This book is presented in two parts, the first part by Horsfall and Fowler deals with the bionomics of this major pest species, and the second part by Moretti and Larsen describes its embryology.

The section on bionomics contains a very large number of observations on the egg, larva, pupa and adult, treated rather as separate entities than as the continuous life history of a species. The tendency seems to have been to catalogue rather than to describe, and the summary (no discussion is presented in this section) does little to synthesize. However, the section does provide an excellent source of references for the student of aedine mosquitoes and it includes very useful instructions for colonization of the species in the laboratory.

The section on embryology provides the most detailed study of organogenesis in the genus *Aedes,* also it is the only detailed study of a mosquito which overwinters in the egg stage. It is straight forward histology using the light microscope. There are 96 photographs of various stages and organs during development, some of those taken at the earlier stages are good, but those taken during the later stages would have been better replaced by a few clear diagrams, or at least considerably enlarged. Interpretation of the illustrations is made more difficult by the way in which they are set up, at least six pages are arranged so that the book has to be turned in order to read the captions.

The book will be a useful reference work to all those engaged in the study of mosquitoes.

—*Anne Hudson*

BARBARA COLFAXIANA SISKIYOUANA (KFT.), A PEST IN CONES OF *ABIES GRANDIS*.

A. F. HEDLIN and D. S. RUTH
Department of the Environment, Canadian Forestry Service,
Pacific Forest Research Centre, Victoria, British Columbia

Barbara colfaxiana siskiyouana (Kft.) is a member of the family Olethreutidae, of which a number are cone feeders. Keen (1958) reported it as being a pest on a number of species of *Abies* probably throughout the range of hosts. In recent years, it has caused considerable damage to cones of *Abies grandis* (grand fir) on southern Vancouver Island. Observations reported here were made in 1971, 1972 and 1973 on grand fir, and they generally agree with those made earlier by Keen for the western United States.

In 1973 eggs were observed during the period from April 13 to May 1 and larvae from May 8 to July 30. Larval head capsules, based on 346 measurements, ranged in width from 0.216 to 1.410 mm, slightly larger than those of *B. colfaxiana* in Douglas-fir cones (Hedlin 1960). Pupae were first observed on July 10 and were present in cones throughout the winter until April.

Adults emerge in April and oviposit on the bracts of young cones. Eggs were laid on bracts near the cone extremities; none were seen at the mid portion of the cone. At first the young larvae feed on the edges of the cone scales but later tunnel within the scales towards the axis of the cone. By late June, they begin to feed on the seeds and scale tissue by tunneling spirally around the axis. Two or more larvae in the same cone construct parallel separate tunnels. During July, the larvae construct silken pitch-coated cocoons perpendicular to the cone axis. Pupation occurs with the anterior end toward the cone exterior. Infested cones remain on the tree over winter. Normally the moths emerge the following spring but some remain in prolonged diapause and emerge one or more years later.

Insect feeding causes the cone scales to die and turn brown; by the end of July, damage is readily apparent from the exterior of the cone. The feeding causes a heavy flow of pitch which fuses the cone scales and prevents the normal disintegration of cones in autumn. Of 185 cones collected at random from 3 trees, 27% were infested. Multiple infestations are common. Twenty cones collected in 1973 were infested by a total of 93 insects with an average of 4.65 (range 1 to 17) per cone. Cones infested by at least two insects suffered 100% seed loss. This suggests that seed collectors should avoid all cones obviously infested by this insect.

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NATIVE PARASITES OF THE LARCH CASEBEARER, *COLEOPHORA LARICELLA* (LEPIDOPTERA: COLEOPHORIDAE), IN THE WEST KOOTENAY AREA OF BRITISH COLUMBIA

GORDON E. MILLER[1] and THELMA FINLAYSON[1]

ABSTRACT

Thirty-two species of parasites and hyperparasites were reared in 1973 from a total of almost 103,000 larch casebearers, **Coleophora laricella** (Hbn.), collected at eight locations in the West Kootenay area of British Columbia. The two highest casebearer populations were at Fruitvale and Shoreacres, with densities of 150 and 130 cases per 100 fascicles respectively. The highest incidence of parasitism was 17.7% at Rossland, where the host density was just under 100 cases per 100 fascicles. The **Dicladocerus** spp. complex comprised 40.7% of the total parasitism and was most abundant at Rossland, Arrow Creek, Christina Lake, Sheep's Creek, and Yahk; **Spilchalcis albifrons** (Walsh) comprised 23.6% of the total and was the most abundant parasite at Shoreacres, Christina Lake, and Fruitvale; and **Bracon pygmaeus** (Prov.) comprised 6.8% of the total and was the most abundant parasite at Anarchist Summit.

Introduction

The larch casebearer, *Coleophora laricella* (Hbn.) (Lepidoptera: Coleophoridae), was first discovered in western North America on western larch, *Larix occidentalis* Nutt. at St. Maries, Idaho, in 1957 (Denton 1958). It apparently entered southeastern British Columbia before 1966 and by 1973 extended along the international border from Anarchist Summit east to Roosville, and north to the Cranbrook, Lardeau, and Nelson areas. Its range seems to have been relatively stable in British Columbia since 1968.

Little is known of the native parasites of the larch casebearer in western North America. Bousfield and Lood (1973) listed 20 species of parasites and hyperparasites from Montana, Idaho and Washington; and Denton (1972) found 16 species at Ste. Maries, Idaho, with an aggregate parasitism of 17%. The only report on the impact of individual native parasite species on casebearer populations is by Bousfield and Lood (1970) for Washington, Idaho and Montana. In British Columbia, Andrews and Geistlinger (1969) reared nine species of parasites and hyperparasites from small numbers of casebearers collected from 1966 to 1968. The total parasitism was 0.69% in 1966, 0.22% in 1967, and 4.0% in 1968.

The objectives of the work reported upon here were to determine the identities and impact of native parasites on the larch casebearer in the West Kootenay area of British Columbia in 1973.

Materials and Methods

Casebearers were collected on May 8-9 (Collection 1), mainly as fourth instar larvae, and on May 23-25 (Collection 2), mainly as pupae. Samples were collected at eight locations: Anarchist Summit, Cascade, Shoreacres, Rossland, Sheep's Creek cutoff (12 miles south of Salmo), Fruitvale, Arrow Creek, and Yahk (Fig 1).

In each collection, 10 to 15 trees were sampled at four to six feet (1.2 to 1.8 m) and at 10 to 12 feet (3.0 to 3.7 m). Five primary branches were taken from the full circumference of the tree at each height. Rearing was done mainly in 1 ft^3 (0.283 m^3) cages constructed from corrugated

[1]Graduate student and Associate Professor, respectively, Simon Fraser University, Burnaby 2, B.C.

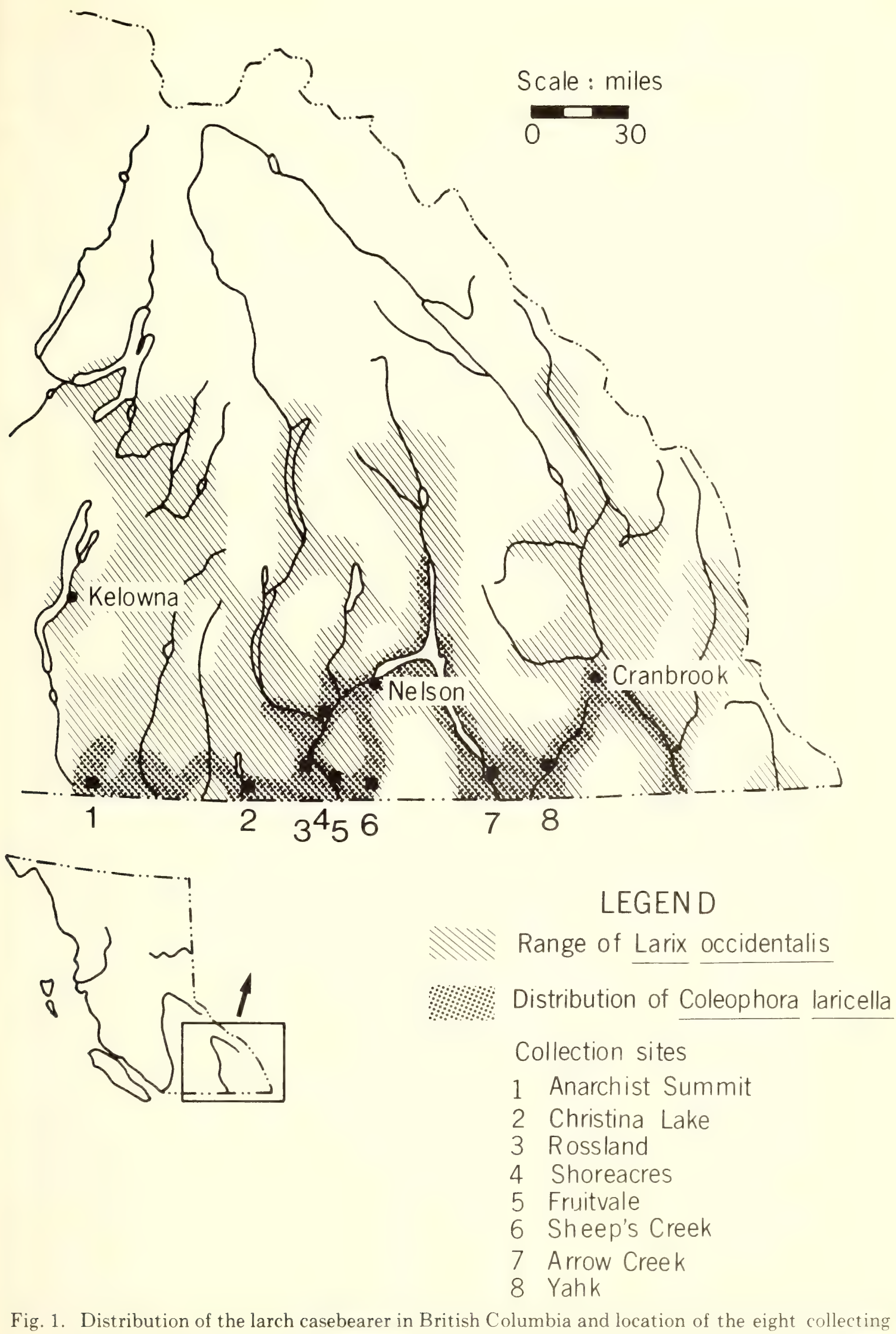

Fig. 1. Distribution of the larch casebearer in British Columbia and location of the eight collecting sites. (Adapted from R. F. Shepherd and D. A. Ross, "Problem analysis: larch casebearer in B.C." Unpublished Internal Report BC-37, Pac. For. Res. Cent., Victoria, B.C., 1973.)

cardboard, one side of which was replaced by fine Dacron mesh. Parasites were collected daily and preserved in 70% ethanol.

The number of fascicles per inch (2.5 cm) of branch was calculated by measuring the length and number of fascicles in 100 branches from each collection. When emergence of moths and parasites had ceased, all the branches were measured and the total numbers of fascicles estimated from the samples.

The number of casebearers in each collection was determined by removing the pupal cases by hand and counting them. Unemerged parasites were detected by immersing the cases in warm 10% KOH for 15 minutes and then examining them under the microscope. Unemerged parasites were not identified to species or genus.

Percentage parasitism was calculated by assuming that only one parasite emerged from each case. This may not be an entirely valid assumption, although Bousfield and Lood (1973) found a low incidence of more than one parasite emerging from a single case.

Results

A total of 102,947 cases were collected and reared, 40,695 in Collection 1, and 62,252 in Collection 2. A total of 4,459 specimens of 32 species of hymenopterous parasites and hyperparasites emerged, 543 from Collection 1 and 3,916 from Collection 2. Sixteen of the species could be named, and the remainder could be named to genus only. The 32 species were composed of 7 Ichneumonidae, 1 Braconidae, 1 Chalcididae, 14 Eulophidae, 4 Pteromalidae, 1 Mymaridae, and 4 Diapriidae. All the parasites from both collections emerged at the same time.

Five of the species have not been recorded previously from the larch casebearer: *Acrolyta* sp., *Hyposoter* sp. (Ichneumonidae); *Melittobia* sp., *Diglyphus* sp. (Eulophidae); *Cyrtogaster vulgaris* Wlkr. (Pteromalidae); and *Anaphes* sp. (Mymaridae). As only one specimen of each of the first three of these and of *C. vulgaris* was reared, it is possible that these few came from hosts other than the larch casebearer which were accidentally included in the collections. This may also be true for the other two, *Diglyphus* sp. and *Anaphes* sp., although they were present in sufficiently large numbers, 107 and 24 specimens respectively, to suggest that they emerged from the larch casebearer.

The remaining parasite species reared in this work have been recorded on the larch casebearer from various areas in North America. Species that were previously recorded only from eastern North America (Webb 1953) are: *Itoplectis vesca* Tow. (Ichneumonidae); *Eulophus* sp., *Euderus cushmani* (Cwfd.), *Elachertus proteoteratis* (How.), *Cirrospilus pictus* (Nees), *Chrysocharis* (*Kratochviliana*) *laricinellae* (Ratz.) (Eulophidae); *Telenomus* spp. and *Trissolcus* sp. (Diapriidae). Species taken previously in Washington, Idaho, and Montana (Bousfield and Lood 1973; Denton 1972) but representing new records for British Columbia are: *Gelis* sp., *Pristomerus* sp. (Ichneumonidae); *Bracon pygmaeus* Prov. (Braconidae); *Tetrastichus dolosus* Gah., *Achrysocharella* sp., *Zagrammosoma americanum* Gir. (Eulophidae); and *Habrocytus phycidis* Ashm., and *Catolaccus aeneoviridis* (Gir.) (*Pteromalidae*). Species found previously in both eastern and western North America, including British Columbia (Andrews and Geistlinger 1969; Bousfield and Lood 1973; Denton 1972; Webb 1953) are: *Gelis tenellus*

Parasite Species	Arrow Creek		Anarchist Summit		Christina Lake		Fruitvale		Rossland		Shoreacres		Sheep's Creek		Yahk	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Braconidae																
Bracon pygmaeus Prov.	8	0.1	5	0.7			2	*	1	*	16	0.2				
Eulophidae																
****Dicladocerus** spp. (3)	1	*	1	0.1	128	2.3	25	0.3	93	4.3	54	0.6	21	0.3	2	3.7
Pteromalidae																
Mesopolobus sp.									4	0.2	11	0.1				
Additional species less than 0.1%							3	*								
Unemerged Parasites	6	0.1	4	0.5	40	0.7	18	0.2	48	2.2	39	0.5	12	0.2	1	1.9
Totals	15	0.2	10	1.3	168	3.0	48	0.5	146	6.7	120	1.4	33	0.5	3	5.6

*Less than 0.1% **Includes **Dicladocerus westwoodii Westw.**

Table I. Numbers and percentages of parasites reared from larch casebearers collected on May 8-9 at eight locations in British Columbia.

(Say) (Ichneumonidae); *Spilochalcis albifrons* (Walsh) (Chalcididae); *Dicladocerus* spp. (including *D. westwoodii* Westw.), and *Tetrastichus ecus* Wlkr. [=*T. xanthops* (Ratz.)] (Eulophidae). *Mesopolobus* sp. [=*Amblymerus* sp.] (Pteromalidae) has been recorded only from the western United States and British Columbia (Andrews and Geistlinger 1969; Bousfield and Lood 1973; Denton 1972). *Scambus decorus* Wly. (Ichneumonidae) was previously recorded on the larch casebearer only in British Columbia (Andrews and Geistlinger).

Seven parasite species were reared from Collection 1 of May 8-9 (Table I). The highest aggregate parasitism was 6.7% at Rossland, followed by 5.6% at Yahk and 3.0% at Christina Lake. Three species of *Dicladocerus*, including *D. westwoodii*, were the most abundant parasites in this collection.

Thirty-two species of parasites, i.e. all the species found in the survey, were reared from Collection 2 of May 23-25 (Table II). The highest aggregate parasitism of 17.7% occurred at Rossland, followed by Shoreacres with 6.8%, Arrow Creek with 4.0%, Anarchist Summit with 3.4% and Christina Lake with 2.9%. The most abundant species in this collection were the *Dicladocerus* spp. complex, *S. albifrons*, and *B. pygmaeus*.

Species that occurred in percentages less than 0.1% at any of the locations are not included in the tables. They are: *G. tenellus, I. vesca, Pristomerus* sp., *Hyposoter* sp., *T. dolosus, Eulophus* sp., *E. proteoteratis, C. pictus, C. laricinellae, Melittobia* sp., *H. phycidis, C. aeneoviridis, C. vulgaris,* and three species of *Telenomus*.

G. tenellus, Acrolyta sp., *E. cushmani, E. proteoteratis, C. pictus, C. aeneoviridis,* and *C. vulgaris* were reared only from casebearers collected at a height of four to six feet. *Eulophus* sp., *Melittobia* sp., *C. laricinellae,* and *Telenomus* spp. were reared only

Place	Collection Number	Number of Cases	Number of Parasites Reared	Percentage Parasitism	Number of Cases per 100 Fascicles	Number of Parasites per 100 Fascicles
Arrow Creek	1	6,874	15	0.2	72	0.2
	2	7,036	280	4.0	52	2.0
Anarchist Summit	1	767	10	1.3	13	0.2
	2	912	31	3.4	8	0.3
Christina Lake	1	5,596	168	3.0	68	2.1
	2	6,695	194	2.9	54	1.6
Fruitvale	1	9,899	48	0.5	150	0.7
	2	11,867	260	2.2	114	2.5
Rossland	1	2,165	146	6.7	81	5.5
	2	10,442	1,848	17.7	67	14.0
Shoreacres	1	8,546	120	1.4	130	0.1
	2	15,359	1,051	6.8	113	7.8
Sheep's Creek	1	6,794	33	0.5	93	0.5
	2	9,738	248	2.5	68	1.7
Yahk	1	54	3	5.6	1.5	0.08
	2	193	4	2.1	1.0	0.02

Table III. Summary of rearings of larch casebearers collected at eight locations in British Columbia showing the numbers of cases incubated, the numbers and percentages of parasites reared, and the numbers of cases and parasites per 100 fascicles.

Parasite species	Arrow Creek		Anarchist Summit		Christina Lake		Fruitvale		Rossland		Shore-acres		Sheep's Creek		Yahk	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ichneumonidae																
Scambus decorus Wly.							2	*			8	0.1				
Gelis sp.	2	0.1					4	*			1	*	2	*		
Acrolyta sp.															1	0.5
Braconidae																
Bracon pygmaeus Prov.	25	0.4	20	2.2	3	*	8	0.1	16	0.2	178	1.2	22	0.2	1	0.5
Chalcididae																
Spilochalcis albifrons (Walsh)	26	0.4			151	2.3	165	1.4	320	3.1	389	2.5	3	*	2	0.5
Eulophidae																
****Dicladocerus** spp. (3)	121	1.7	1	0.1	13	0.2	9	0.1	1122	10.7	57	0.4	166	1.7	1	0.5
Tetrastichus ecus Wlkr.	1	*			1	*	1	*	53	0.5	86	0.6				
Achrysocharella sp.									10	0.1	16	0.1	4	*	1	0.5
Euderus cushmani (Cwfd.)			2	0.2												
Diglyphus sp.					2	*	3	*	56	0.5	43	0.3	3	*		
Zagrammosoma americanum Gir.									10	0.1						
Pteromalidae																
Mesopolobus sp.	28	0.4			2	*	19	0.2	37	0.4	53	0.3	19	0.2		
Mymaridae																
Anaphes sp.									24	0.2						
Diapriidae																
Trissolcus sp.									1	*	9	0.1				
Additional species less than 0.1%	1	*					2	*	16	0.1	22	0.1				
Unemerged Parasites	76	1.1	8	0.9	22	0.3	47	0.4	183	1.8	189	1.2	29	0.3		
Totals	280	4.0	31	3.4	194	2.9	260	2.2	1848	17.7	1051	6.8	248	2.5	4	2.1

*Less than 0.1% **Includes **Dicladocerus westwoodii** Westw.

Table II. Numbers and percentages of parasites reared from larch casebearers collected on May 23-25 at eight locations in British Columbia.

from casebearers collected at a height of 10 to 12 feet. Not more than two individuals of any of these 11 species were obtained, except for *C. laricinellae* and *Telenomus* spp. where there were five and six respectively. Because there were not sufficient numbers of any of these species present at either height to have any significance, the collections taken at the two heights were pooled and are reported as single collections in the tables.

The *Dicladocerus* spp. complex comprised 40.7% of the total parasitism. This complex was the most abundant at Rossland, Arrow Creek, Christina Lake, Sheep's Creek, and Yahk. Next in importance was *S. albifrons* which comprised 23.6% of the total parasitism and was the most abundant species at Shoreacres, Christina Lake, and Fruitvale. *B. pygmaeus* comprised 6.8% of the total and was the most abundant parasite at Anarchist Summit. In decreasing importance were *Mesopolobus* sp., comprising 3.9%, *T. ecus* comprising 3.2%, and *Diglyphus* sp. comprising 2.4%. The remaining 24 species accounted for 19.4% of the parasitism. *S. albifrons, T. ecus* and *Diglyphus* sp. were reared only from cases collected on May 23-25.

Areas of highest overall host density were Fruitvale and Shoreacres with 150 and 130 cases per 100 fascicles respectively in Collection 1 (Table III). However, the percentage parasitism was highest in both collections at Rossland where host density was 81 and 67 cases per 100 fascicles in Collections 1 and 2 respectively. Calculation of the number of parasites per 100 fascicles indicated that they were most abundant at Rossland with 14.0 and Shoreacres with 7.8, both in Collection 2.

Discussion

Seasonal differences in parasitism were apparent in the two collections. Only seven species emerged from Collection 1 and these represented about 12% of the total parasitism, whereas 32 species emerged from Collection 2, constituting about 88% of the total. Reasons for the relatively low parasitism in early May could be either that the host casebearers were not at the correct stage for attack or that adults of the majority of the parasite species had not yet emerged. There may also have been an accumulation of parasites in the hosts over a period of time because emergence from the two collections took place at the same time.

Differences in parasitism between the various plots cannot be explained on the basis of host density. At Shoreacres and Fruitvale, where casebearer densities were greatest, the aggregate parasitism was 6.8% and 2.2% respectively, whereas at Rossland, where host density was between one-half to two-thirds that of Shoreacres and Fruitvale, the parasitism of 17.7% was highest. At Yahk, where host density was lowest, parasitism in Collection 1 amounted to 5.6% which was the third highest of any of the areas. Because the parasites must have transferred to the larch casebearer from other hosts in the area, the most likely cause of variation in species numbers and densities is the extent of occurrence of alternate hosts at each site.

The presence of *C. laricinellae* at Shoreacres and Rossland is interesting because its origin in British Columbia is unknown. It was imported into the western United States from Austria and England for release as a biological control agent against the larch casebearer in 1972 (Ryan and Denton 1973). However, no releases have been made in British Columbia and the closest release site in the

United States is over 200 miles from the locations where they were taken here. The possible explanations for its presence are discussed by Ryan *et al* (in press).

The previously unrecorded species were probably found in the present survey because of the large numbers of cases reared. Although many of them were present in very small numbers, it is significant that they will attack the larch casebearer, and it is conceivable that under certain conditions of weather and host density that they could become regulatory factors of consequence. *Dicladocerus* spp., *S. albifrons,* and *B. pygmaeus* probably have the greatest potential for reducing the numbers of larch casebearer because of their wide distribution and greater abundance.

Acknowledgments

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OCCURRENCE OF APPLE LEAF ROLLERS (LEPIDOPTERA: TORTRICIDAE) AND THEIR PARASITES IN THE OKANAGAN VALLEY, BRITISH COLUMBIA

D. F. MAYER[1] AND B. P. BEIRNE
Pestology Centre, Department of Biological Sciences,
Simon Fraser University, Burnaby 2, British Columbia

ABSTRACT

Seven species of leaf rollers feed on apple in the Okanagan Valley. Five of them, including two of the three most common species, were not previously recorded as feeding on apple there. Six of the species have alternative host plants of which rose is the most important. A short key to final instar larvae of six of the species is included. Thirty-seven species of parasites were reared, of which eight may have some significance in control.

Introduction

Apple-feeding species of leaf rollers in the Okanagan Valley were investigated in 1972. The species, their food plants, and their natural enemies are listed here; aspects of their ecology are discussed elsewhere (Mayer and Beirne, in press).

The Leaf Rollers

Seven species were found feeding on apple in the Okanagan Valley, between Kelowna and Okanagan Falls. An earlier survey by Venables (1924) revealed four species of which two were not found in the 1972 survey. All seven are univoltine. *Archips argyrospilus* and *A. rosanus* overwinter as eggs which hatch when apple is in the one-half-inch green bud stage of development. The newly-hatched larvae disperse, often windborne. The five other species overwinter as larvae. All seven species reduce potential fruit set by feeding on the developing buds and leaves. Blossom feeding is common. On apple the larva rolls a single leaf, often attached to a fruit. On plants with smaller leaves such as privet two to five leaves may compromise the nest. The seven species in approximate order of economic significance to apple are as follows.

[1]Present address: Department of Entomology, Washington State University, Pullman, Washington.

(a) *Archips argyrospilus* (Walk.), the fruit-tree leaf roller, has been the dominant leaf roller on apple in the Okanagan Valley since the early 1920's. It was still dominant in 1972, comprising from 19 to 99% of the apple leaf rollers in different localities, although it was exceeded in numbers by *A. rosanus* and by *Pandemis limitata* in locations near Summerland. Apple, followed by rose and antelope bush (*Purshia tridentata* (Pursh)), are the primary host plants. Other food plants are birch (*Betula* sp.), squaw current (*Ribes cereum* Dougl.), Oregon grape (*Mahonia nervosa* (Pursh)), Russian olive (*Eleangus angustifolia* Pall.), walnut (*Juglans regia L.*), and willow (*Salix* sp.). Feeding tests showed that the larvae will feed on leaves of almost any available shrub or tree rather than starve. This species is closely related to *A. rosanus* but repeated laboratory attempts to interbreed them resulted in a single mating but no eggs. Twenty species of parasites were reared.

(b) *A. rosanus* (L.), the European leaf roller, was common (25 to 80%) on apple in the Summerland district in 1972 but was not previously recorded on that plant in the Okanagan Valley. The usual primary host plant is privet (*Ligustrum vulgare* L.).

Other primary host plants are rose and red-osier dogwood (*Cornus stolonifera* Michx.). It was also found feeding on alder (*Alnus* sp.), chokecherry (*Prunus virginiana* L.), hawthorn (*Crataegus douglasii* Lindl.), maple (*Acer* sp.), Russian olive, walnut, and willow. It was not found feeding on currant though this is a host plant in Eastern North America (Whitehead 1926). Twenty-eight species of parasites were reared.

(c) *Pandemis limitata* Rob., the three-lined leaf roller, was common (2 to 42%) on apple in the Summerland district in 1972 though not recorded previously as feeding on it in the Okanagan Valley. Other primary host plants are rose and dogwood. It was also found feeding on birch, maple, and willow. Though univoltine in the Okanagan Valley it is bivoltine about 300 miles south in Washington State. The feeding habits differ from those described for Eastern North America. In the Okanagan Valley the larva first feeds on the undersurface of a leaf under webbing and later does not roll leaves; usually it is found on leaves not fed upon by other species of leaf rollers. In the East (Hall 1929, Gilliatt 1932) the early instar larva establishes feeding-sites in leaves rolled and partly fed upon by other species of leaf rollers. Nine species of parasites were reared. In one locality larvae were found to be infected with a granulosis virus that killed them in the final instar.

(d) *Platynota idaeusalis* (Walk.), the tufted apple bud moth, was not common (3%). Apple and rose are primary host plants and it was also found feeding on willow. In New York the larva overwinters as two different sizes (Chapman and Lienk 1971) but only as one in the Okanagan Valley. One parasite species was reared.

(e) *Syndemis afflictana* (Walk.), the fall dead-leaf roller, was found only on apple (2%). It overwinters as a final-instar larva, whereas the other species that do not overwinter as eggs do so as partly-grown larvae. The majority of the larvae were found in living rolled leaves whereas in New York (Chapman and Lienk 1971) most of the larvae construct nests from dead leaves or cause a living leaf to die by partly severing the petiole.

(f) *Choristoneura rosaceana* (Harr.), the oblique-banded leaf roller, was the dominant species on apple in the Okanagan Valley up to the 1920's (Venables 1924) but it is now rare. It was found in 1972 in a single location near Okanagan Falls and only in trace amounts, feeding on apple.

(g) *Argyrotaenia dorsalana* (Dyar), was found, infrequently (1%), on apple and rose. The recorded host plants are Pinaceae (Powell 1964) and oak (Freeman 1958).

Parasites

The following parasites were reared from leaf-rollers in the Okanagan Valley. The host species, when identifiable, are indicated by the letters in parenthesis, which are from the list above. Only eight of the 38 species (marked with asterisks below) were reared more than five times and are therefore of possible control significance.

Ichenumonidae: **Itoplectis quadricingulata* (Prov.) (a,b,c); *Hercus pleuralis* (Prov.) (b); *Scambus tecumseh* (Harr.) (b); *Exochus nigripalpis tectulum* Townes (a); *Phytodietus* sp. (b); *Glypa* sp. (c); *Acropimpla albortica* (Cress.) (b); **Diadegma* sp. 1 (b,c,d); *Diadegma* sp. 2 (a); *Gelis* sp. (a); *Pimplinae* (b).

Braconidae: **Microgaster epagoges* Gahan (a,b,c); **Apanteles cacoeciae* (Riley) (a,b,c,g); **Habrobracon xanthonotus* (Ashm.) (a); *Onco-*

phanes americanus (Weed) (b); *Agathis annulipes* (Cress.) (a,b); *Agathis* sp. (b); *Apanteles* sp. No. 49 (b).

Trichogrammatidae: *Trichogramma minutum* Riley (a,b,).

Chalcididae: *Spilochalcis albifrons* (Walsh) (b); *Brachymeria ovata ovata* (Say) (b,c).

Eulophidae: *Eulophus anomocerus* (Crawf.) (a); *Sympiesis marylandensis* Girault (b); *Elachertus aeneoniger* (Girault) (b); *Elachertus cacoeciae* (Howard) (b); *Elachertus* poss. n. sp. (a); *Dicladocerus westwoodii* Westwood (a); *Pediobius* sp. near *lonchaeae* Burks (a).

Elasmidae: *Elasmus atratus* Howard (a,b).

Pteromalidae: *Dibrachys cavus* (Walk.) (a); *Dibrachys* poss. n. sp. (b); *Habrocytus phycidis* Ash. (a,b,c); *Catolaccus aeneoviridis* (Girault) (a,b).

Tachinidae: * *Nemorilla pyste* (Walk.) (a,b); *Compsilura concinnata* (Mg.) (b); **Hemisturmia tortricis* (Coq.) (a,b,c); *Eumea caesar* (Ald.) (a,b); **Pseudoperichaeta erecta* (Coq.) (a,b,c).

Associated Lepidoptera

The apple leaf rollers recorded from the Okanagan Valley by Venables (1924) but not found in the 1972 survey were *Acleris maximana* (Barnes & Busck) and *Aphelia alleniana* (Fern.).

In the 1972 survey three species of leaf rollers were found on primary host plants of apple-feeding species but not themselves on apple: *Acleris forbesana* (McD.) and *Acleris* sp. near *bowmana* (McD.), on dogwood, and *Croesia albicomana* (Clem.), on rose.

Species of Lepidoptera other than leaf rollers that were found feeding on foliage of apple were: *Epinotia rectiplicana* Walsm., *Epinotia* sp., *Hedia ochroleucana* Hbn., and *Exartema punctanum* Walsm. (Olethreutinae); *Filalima demissae* Kief. and *Trachoma walsinghamiella* Busck (Gelechiidae); and *Lithophane georgii* Grt. (Noctuidae).

Key To Leaf Rollers

Key to final-instar larvae of six leaf rollers on apple in the Okanagan Valley, B.C.

1\. Body light green, head darker green 2
—. Body dark green or brownish green, head reddish brown, dark brown, or black 3
2\. Full-grown at about end of apple bloom; relatively sluggish; usually scarce. . . . . **Argyrotaenia dorsalana**
—. Full-grown two or three weeks after end of apple bloom; very active; often frequent. . . . . **Pandemis limitata**
3\. Head brown to black, body dark green; usually common 4
—. Head reddish brown to brown, body brownish to brownish green; usually scarce . . . 5
4\. First thoracic legs brown, remainder green; never on privet . . . **Archips argyrospilus**
—. All thoracic legs greenish; often common on privet . . . . **Archips rosanus**
5\. Body brownish, sometimes with two dark brown stripes; full grown late in summer or early in fall . . . . . **Syndemis afflictana**
—. Body brownish-green, not with stripes; full-grown late in spring or early in summer. . . . . **Platynota idaeusalis**

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INFLUENCE OF STREAM SEDIMENTS ON DISTRIBUTION OF MACROBENTHOS[1]

M. A. BRUSVEN AND K. V. PRATHER[2]
Department of Entomology
University of Idaho
Moscow, Idaho

ABSTRACT

Studies were conducted in the laboratory and field to determine the substrate relationships of five species of stream insects representing the orders Ephemeroptera, Plecoptera, Trichoptera and Diptera. Various combinations of pebble and sand were tested in the presence or absence of cobbles. Substrates with cobble were generally preferred over substrates without cobble. The preference for cobble generally increased as the sediments around the cobble decreased in size. Substrates with unembedded cobble were slightly preferred over half-embedded cobble; completely embedded cobble in fine sand proved unacceptable to most species. Three types of substrate-distribution patterns are recognized; stream insects which inhabit substrate surfaces; interstices; and both substrate surfaces and interstices.

Introduction

Sediment pollution is of increasing concern to stream ecologists. Excessive accumulations of sediment in mountain streams as a result of agricultural practices, logging, road construction, dredge mining, etc. can have serious detrimental effects on the stream biota. The role of sediments in the distribution and abundance of stream benthos has been reported by Pervical and Whitehead (1929), Cummins (1964, 1966), Scott (1966) and others. This paper is concerned with substrate relationships of insects, but we recognize that other trophic levels are also affected by sediments. Influence upon any one trophic level may cause profound side effects on other components in the ecosystem.

This paper attempts to clarify the substrate relationships and ecology of five stream insects studied in the laboratory and field and suggests reasons for specific affinities for certain substrate conditions.

Materials and Methods

Insect-substrate relationships were studied in the laboratory in artificial streams similar to one described by Brusven (1973). Temperature was

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[2]Present address: Third U.S. Army Medical Laboratory, Ft. McPherson, Georgia, U.S.A.

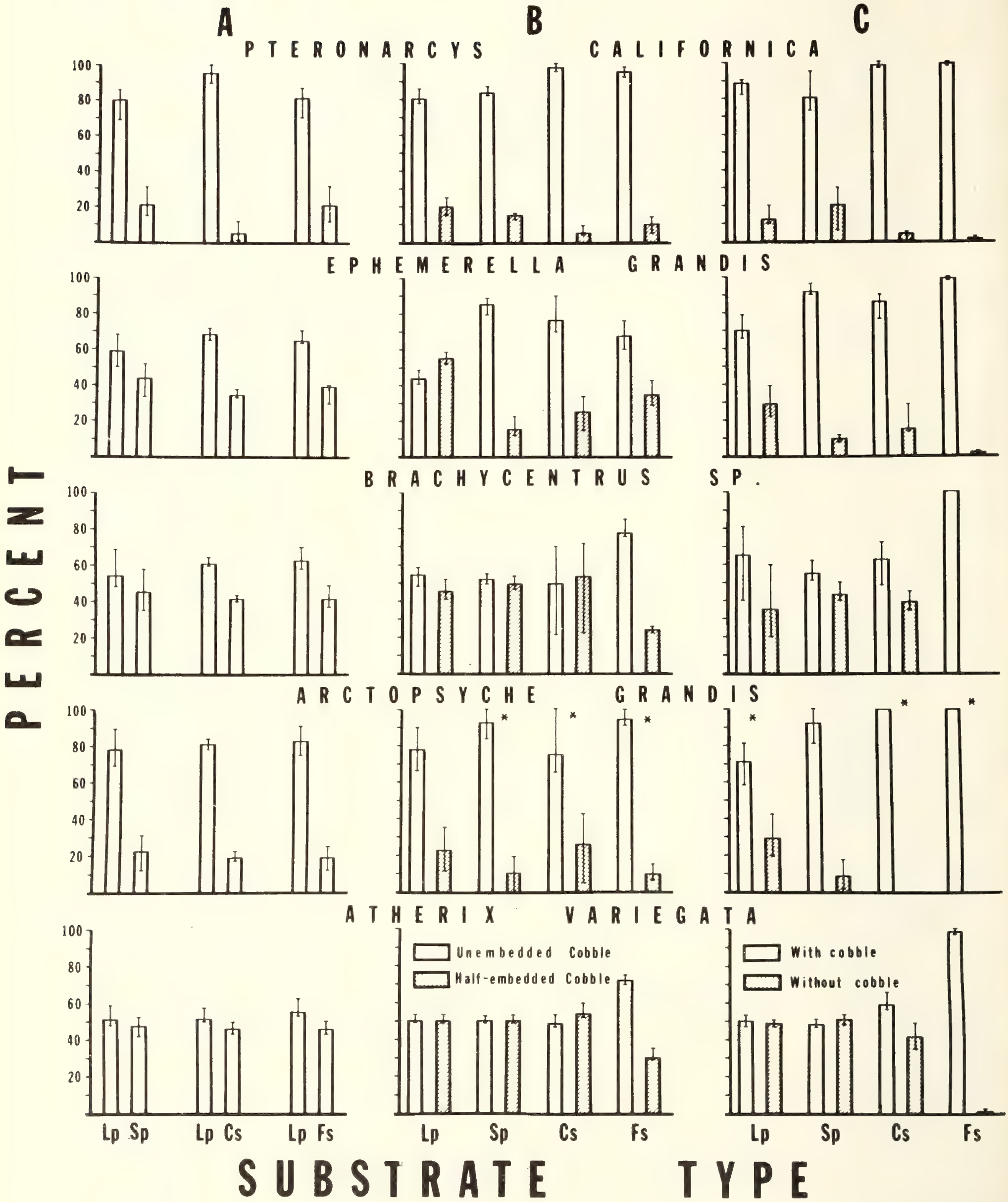

Figure 1. Substrate preference of five species of aquatic insects. A. Preference for two sizes of pebble and sand; B. Preference for unembedded and half-embedded cobble when in presence of pebble and sand; and C. Preference for substrates with and without cobble. Vertical lines indicate extremes of three replications. Lp=large pebble; Sp=small pebble; Cs=coarse sand; Fs-fine sand. *-fewer than 25 insects recovered from test quadrants during one replication.

maintained at approximately 5°C and water velocity at 15 cm/sec with substrates of coarse sand or larger sediments and 8 cm/sec with fine sand. As a bed material fine sand became unstable at velocities greater than 8 cm/sec. Alternating 12-hour dark-light cycles were maintained with artificial lighting and automatic timers. Each test lasted 48 hours.

Five species of stream insects, *Pteronarcys californica* Newport, *Ephemerella grandis* Eaton, *Arctopsyche grandis* (Banks), *Brachycentrus* sp. and *Atherix variegata* Walker, representing the orders Plecoptera, Ephemoptera, Trichoptera and Diptera were studied. The insects were collected in the field and acclimated in a laboratory stream similar to the test stream. Middle and late instar larvae and nymphs were used because they proved less subject to injury when handled than early instars.

Substrate preference experiments were conducted to determine the preference of the insects: among four substrate particle sizes, for totally, partially or unembedded cobble substrates, and substrates with vs. without cobble. Cobble used in this context refers to rocks having diameters of 64-256 mm. Rocks averaging 115 mm in diameter were used during cobble preference tests; six of these were uniformly spaced in each of the four test quadrants of the stream. Sediments of less than cobble size were screened into four size classes: large pebble (12.0-25.0 mm), small pebble (6.0-12.0 mm), coarse sand (2.5-6.0 mm) and fine sand (1.0-1.5 mm).

The insects were uniformly distributed in the test quadrants of the stream at the beginning of each test. A minimum of 35 specimens of a species was introduced into the stream; recovery of 25 live specimens from test quadrants was considered necessary to validate a test. Each test was replicated three times.

In addition to recording the number of insects recovered from each stream section and respective substrate types, the number of insects on or under cobble was recorded and expressed as a percentage of the total number of insects in each quadrant. This was done to determine the role played by cobble in microhabitat distribution as the sediment surrounding cobble increased or decreased in size.

In addition to laboratory studies, numerous field investigations were conducted and provided a basis for an autecological analysis of the species in question in their natural environs.

RESULTS

Comparative Insect-Substrate Performance

Five species of aquatic insects in the laboratory demonstrated differential preferences when tested on various combinations of substrate particle sizes (Fig. 1A). The stonefly, *Pteronarcys californica* Newport, and the caddisfly, *Arctopsyche grandis* Banks, preferred a substrate of large pebble over small pebble and coarse and fine sand. The mayfly, *Ephemerella grandis* Eaton, and the caddisfly, *Brachycentrus* sp., displayed a moderate preference for large pebble over coarse and fine sand, but little distinction between large and small pebble. The dipteran, *Atherix variegata* Walker, showed little preference for one sediment over another.

When embeddedness of cobble was added as a variable, *P. californica* and *A. grandis* preferred fully exposed over half-embedded cobble when in association with all four surrounding sediment sizes (Fig. 1B). *E. grandis* preferred exposed cobble with surrounding sediments of small pebble

and coarse and fine sand. *Brachycentrus* sp. and *A. variegata* preferred exposed to half-embedded cobble with surrounding sediment of fine sand; however, no preference was indicated for the two embeddedness values when cobble was associated with large and small pebble and coarse sand.

P. californica, E. grandis and *A. grandis* preferred cobble over substrates without cobble (Fig. 1C), while *Brachycentrus* sp. and *A. variegata* showed a high preference for cobble only when cobble was in the presence of fine sand. A small to moderate preference was indicated by *Brachycentrus* sp. for cobble over substrates without cobble when the latter had large and small pebble and coarse sand associated with it. *A. variegata,* on the other hand, showed no preference for substrates with cobbles underlain with pebbles.

Cobbles were differentially selected as places of inhabitation when placed in various combinations with pebble and sand (Fig. 2A). The results from this test differed from the previous test in that specific associations with cobble as a microenvironment were determined as opposed to general distribution in test quadrants having or not having cobble. The data indicate that the affinity of *P. californica, E. grandis* and *A. grandis* for cobble generally increased as the sediments surrounding cobble decreasd in size. A similar relationship for the case-bearing caddisfly, *Brachycentrus* sp. was not noted. The dipteran, *A. variegata,* had affinities to cobble only when cobble was in the presence of fine sand.

Adding the embeddedness of cobble as a factor influencing microdistribution, the data (Fig. 2B) indicate a weak to moderate preference for unembedded over half-embedded cobble. Like the previous test (Fig. 2A), *Brachycentrus* sp. had higher affinities to both unembedded and half-embedded cobbles than all other species when these cobbles were tested with various combinations of smaller surrounding sediments. *A. variegata* reflected low affinity to cobbles except when the latter were in the presence of fine sand. In this respect, the results were similar to the previous test when cobble was unembedded.

Autecology

Laboratory studies provided control over such substrate variables as sediment size and type, presence or absence of cobble and embeddedness of cobble but arrangement and segregation of sediments in the laboratory was artificial. The substrate characteristics of natural streams are heterogeneous, often precluding microenvironmental interpretation of insect-substrate relationships. Therefore, in order to integrate the two aspects of laboratory results and field observations, the following is an autecological analysis of the five species studied with respect to their substrate affinities and microenvironment:

Ephemerella grandis Eaton. This mayfly occurs in moderately fast, clean to lightly sanded, cobble streams. Nymphs occur in the interstices of pebble and gravel or on the surface of cobble. In the laboratory they often sought refuge in depressions of rocks. In heavily sanded streambeds, nymphs demonstrated increased affinities for cobble. Unembedded cobbles were much preferred to partially embedded cobbles when in the presence of sands. Large numbers of nymphs were often encountered in filamentous tails of moss (*Fontinalis* sp.) attached to the downstream sides of rocks. Being

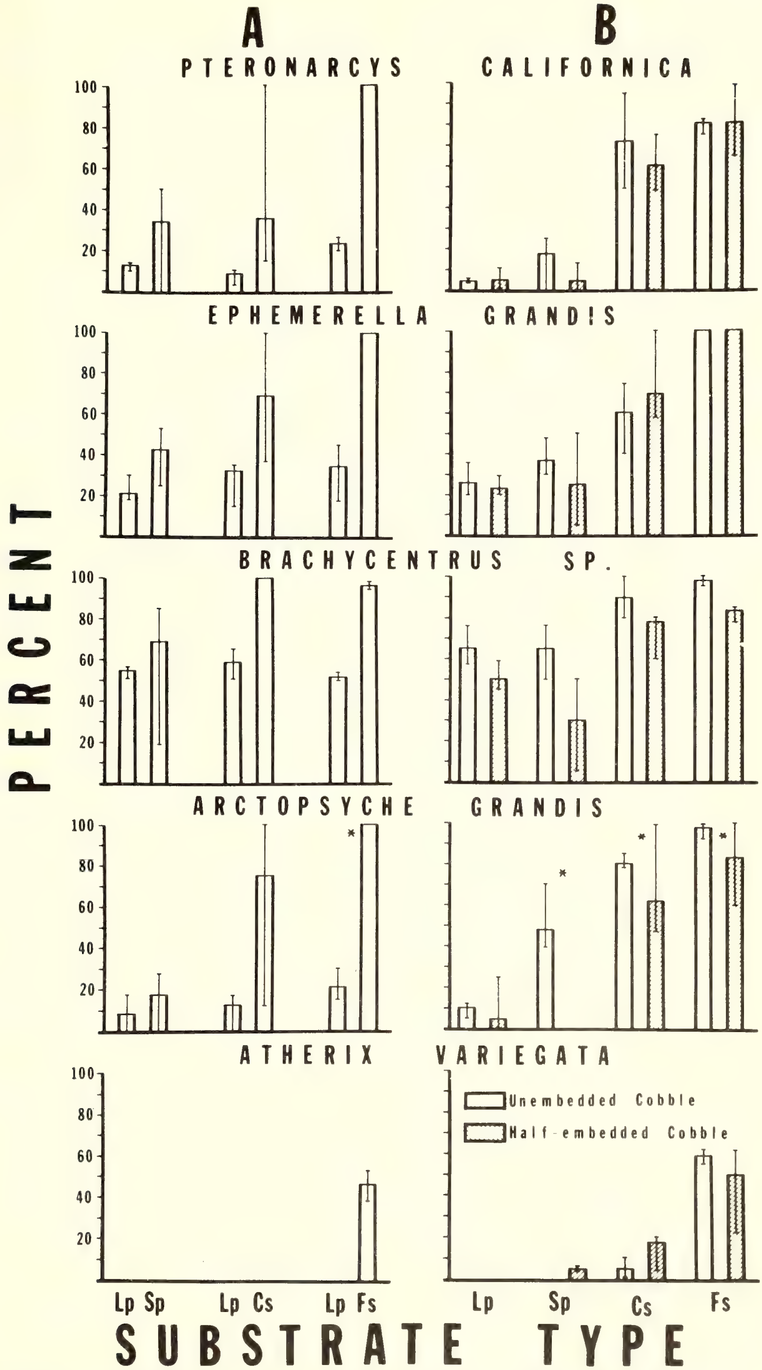

Figure 2. Substrate preference of five species of aquatic insects. A. Percentage of insects recovered on or under unembedded cobble-surrounding substrate test; B. Percentage of insects recovered on or under half- and unembedded cobble when cobble was tested in relation to four surrounding substrate sizes. Vertical lines indicate extremes in replications. Lp=large pebble, Sp-small pebble; Cs=coarse sand; Fs=fine sand. *=fewer than 25 insects recovered from test quadrants during one replication.

cryptically colored and lethargic, they often escape detection. The rough, spiny body surface of this mayfly undoubtedly restricts its distribution to accessible microhabitats.

Pteronarcys californica Newport. Mature nymphs of this stonefly are some of the larger in the Plecoptera. The species has a multiple-year life with overlapping generations. It occurs in moderately fast, rocky streams where the rocks are largely unembedded in fine sediments. Although sands are often present in small to moderate quantities, the species still abounds where the lower surface or sides of cobbles are available for retreat. In substrate preference tests in the laboratory, older age class nymphs of this species did not extensively utilize pebble substrates when cobble substrates were present; however, when cobble was unavailable, pebble substrates were highly selected over fine sediments (Fig. 1A). Affinities with the undersurface and sides of cobbles did not occur except where cobbles were in the presence of sand, particularly fine sand (Fig. 2A). The species is secretive during the day, residing commonly under rocks or shallow interstices.

Brachycentrus sp. This is a case-bearing caddisfly, the larvae of which are poorly known taxonomically. The cases are square in cross section and made of plant material. It occurs most commonly in slow to moderate streams. Preferred bottom types are usually gravel with cobble. Filamentous tails of moss and algae as well as wood pieces lodged in the stream often harbor large concentrations. Unlike many stream insects, this species lives largely on the surface of the substrate rather than in the interstices or under rocks. Unembedded cobble is only slightly preferred over half-embedded cobble (Fig. 1B). Owing to its nonsecretive behaviour and clumped distribution, it is vulnerable to vertebrate predation.

This caddisfly shows a positive correlation between body size and transverse channel distribution. Late instars frequent deeper, faster water than early instars, which tend to be close to shore.

Larvae are relatively sedentary, at least during the day. Their orientation is upstream. The mesothoracic and metathoracic legs are extended and elevated, presumably as a means of filtering particulate organic matter from the water for food. A conspicuous diel drift cycle has been reported for this species (Brusven, 1970), drift being the greatest during the night.

Arctopsyche grandis Banks. The larvae of this caddisfly are net spinners; the nets catch particulate organic matter upon which they feed. The larvae occur mostly on rocky, gravelly riffles were the nets are usually attached to the roughened edges of pebbles, between pebbles and coarse sand grains, under rocks, or in cracks and fissures in rocks. Unlike the brachycentrid previously discussed, this caddisfly occurs primarily in the interstices of the substrate. A relatively permeable substrate is prerequisite for successful functioning of the nets.

Laboratory studies revealed this species to be remarkably similar to the stonefly, *P. californica*, in substrate preference for all combinations of sediment and cobble tested (Figs. 1-2), i.e. coarse sediments of pebble were preferred over sand, cobble substrates without cobble and unembedded over half-embedded cobble.

Atherix variegata Walker. The larvae of this rhagionid dipteran are occasionally common in gravelly, moderately fast mountain streams of the western United States. The genus is represented by this single species

in North America. Laboratory studies indicated that the larvae had little preference for pebble over fine and coarse sand (Fig. 1A) and that the presence or absence of cobble had little influence on sediment preference except when cobble was associated with fine sand. The larvae showed little affinity for cobble as a microhabitat except when the cobble was associated with fine sand (Fig. 2A). Equipped with ventral prolegs and a fusiform body, the larvae are effective burrowers, living and moving in the interstices of the streambed. It appears to have one of the widest ranges of substrate tolerance of species studied in the laboratory and field and its absence from some streams is likely due to factors other than substrate.

Discussion

The results from this study indicate that sediments influence in a major way benthic composition and micro-distribution in streams. Cummins (1964, 1966) suggested that sediment particle size is a primary factor influencing microdistribution of benthos and that current, water chemistry and food are other important factors.

Vertical distribution was not a principal point of investigation in this study; however, the results revealed obvious distributional differences among the species. Benthic insects can be classified generally into three categories with respect to vertical distribution: those that inhabit substrate surfaces, interstices, and substrate surfaces and interstices. Until recently most quantitative studies have been limited to shallow, surface sediments (5-7 cm). Recent studies by Coleman and Hynes (1970), Mundie (1971), and Bishop (1973), demonstrated that a large percentage of the benthic fauna lives at considerably greater depths. Although the sediment bed in the artificial streams used here was only 7 cm deep, it was apparent that the dipteran *A. variegata* was an interstitial inhabitor, apparently capable of burrowing deep within the streambed given proper sediment size and permeability; *A. grandis* was also an interstitial inhabitor, *Brachycentrus* sp. a substrate-surface inhabitor, and *P. californica* and *E. grandis* combination substrate surface-interstitial inhabitors. The latter classification would probably apply to most species in riffle communities.

We view unembedded or partially embedded cobble as an important substrate component in a viable, diversely-productive mountain stream. Unimpacted cobble permits maximum inhabitation around the cobbles, particularly to insects that cannot burrow, have exoskeletal armature or body size inhibiting interstitial burrowing, or have the habit of living under or on the surface of cobbles. Fine sediments around cobbles tend to produce a "gasket effect" by creating a seal, thereby restricting access to the undersurface of the cobbles or deep sediments except to specialized, burrowing forms such as midge (Diptera: Chironomidae) or tipulid (Diptera: Tiplidae) larvae. The diversity of species is almost always reduced in heavily silted, sanded streams, but these streams may still be productive as indicated by Hynes (1970).

Silt was not used as a test during this study because of the low velocities needed to avoid particle suspension. In an artificial channel, Cummins (1969) using velocities of 3 cm/sec, determined that eight of 10 species of insects tested experienced minor effects when exposed to a skim of silt over the streambed. In a natural stream, Nuttall and Bielby (1973) reported large adverse effects of clay

on stream insects. Sands, particularly fine sands are a more serious pollutant than silt to riffle communities in many Idaho batholith streams because of the associated soils, the gradient, and discharge of the streams. Sands impact the streambed during low flows; silts tend to be displaced in suspension, settling out behind impoundments or in slow, low-gradient reaches.

The critical nature of sediments with respect to insect diversity and productivity in streams is sometimes lessened by development of a carpet of algae over the streambed (Brusven *et al.*, in press). Algal filaments serve as the effective microenvironment of many insects and in some cases replace sediments as places for inhabitation.

The impact of various kinds and amounts of sediments on all stages of insect development is still in a conjectural state. Whereas previous studies have dealt largely with the critical nature of sediments on nymphs and larvae, the egg stage may be the most sensitive stage with respect to sediment pollution. Determination of age-specific effects of sediments on insects is largely unresolved under field conditions. When these questions are answered we shall have a much clearer undrstanding of the role played by sediment pollution in benthic stream ecology.

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OCCURRENCE OF A MIDGE, *OLIGOTROPHUS BETHELI* FELT, ON JUNIPER ON VANCOUVER ISLAND, BRITISH COLUMBIA (DIPTERA: CECIDOMYIIDAE)[1]

N. V. TONKS
Research Station, Agriculture Canada
Sidney, British Columbia

On June 2, 1969, I was asked to examine a planting of *Juniperus sabina* in a nursery at Royal Oak on southern Vancouver Island. There were many dead branchlet tips on each shrub and the planting had an unsightly brown appearance. Numerous small flies were active around the plants and there were many small, elongate, orange-coloured eggs on the new growth. The midges were later identified as *Oligotrophus betheli* Felt, a species not previously recorded in Canada.

Felt (1912) describes this species from individuals reared on *J. utahensis* in Colorado. Foote (1965) records this midge from Colorado and Utah. Appleby and Neiswander (1965) describe it and outline the life history in Ohio under the name *O. apicis,* which Gagne (1967) lists as a synonym of *O. betheli.*

The life history of this species on Vancouver Island is very similar to that described in Ohio. The yellow-orange larvae overwinter in the branchlet tips, where they pupate in the spring. Adults emerge in late April and May to lay eggs on the new growth. These eggs hatch in late May and June and larvae enter the branchlet tips to feed. Each infested tip develops into a brown, fleshy, conical gall containing a single larva.

During 1969 there was a second peak of adult emergence during July, with a third occurring in September. Counts made in August on 2,854 tips from 20 plants in the nursery showed a mean of 23% of the tips infested per plant. Saleability of the crop was seriously reduced because of the discoloured and restricted growth.

Appleby (1965) obtained control of this midge in Ohio with foliage sprays of dimethoate applied in late May, early June, or late June. Excellent control was obtained on Vancouver Island with a foliage spray of Diazinon 50% E.C. at 1 pint per 100 gallons applied in late May. There was no resurgence of midge activity in this planting except on two isolated unsprayed plants. A second application of diazinon was made over the entire planting in mid-August.

There has been no further report of this midge infesting junipers on southern Vancouver Island.

[1]Contribution No. 233, Research Station, Agriculture Canada, Sidney, British Columbia.

Acknowledgements

Dr. R. J. Gagne, Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D.C., identified the flies. Dr. J. F. McAlpine, Biosystematics Research Institute, Canada Department of Agriculture, Ottawa, provided additional information from correspondence with Dr. Gagne.

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BOOK REVIEW

A Catalog of the Diptera of the Oriental Region. Volume I. Suborder Nematocera edited by MERCEDES D. DELFINADO and D. E. HARDY. The University Press of Hawaii, Honolulu, 1973. Pp. 618. $18.50.

A synoptic catalogue is not an easy work to review. When it is well bound, clearly and attractively typeset, and meticulously edited the task is even more difficult. The present work differs in two main respects from its predecessors, the Nearctic Catalogue edited by A. Stone *et al* and the Neotropical Catalogue edited by N. Papavero. The former is a single volume, the latter has a fascicle for each family. Publication of the Oriental Catalogue in three volumes is an excellent compromise. A single volume would have been very bulky and would, for those interested in only one or a few families, have involved an unnecessarily large financial outlay. The other major difference is the inclusion of the full journal citation with each name rather than a date and page reference to an accompanying bibliography. This perhaps increases the bulk of the book, and reduces the bibliography to a selected rather than an almost complete list of relevant papers, but it makes the work so much more convenient to use that I approve the arrangement wholeheartedly.

The catalogue is supposed to be complete through 1970, but a few omissions have been noted. Eleven species of Mycetophilidae of the genera *Macrocera*, *Boletina* and *Symmerus* described or recorded from Taiwan by Sasakawa in 1966 and by Saigusa in 1966 and 1968 are not included. I hope that a list of omissions can be compiled and distributed.

The most striking feature of the fauna as recorded by the catalogue is the enormous number of Tipulidae. The 3223 Oriental species make up 52% of the Nematocera; in the Nearctic region they make up only 29%. The proportion will probably decrease in both regions as other families are more thoroughly studied; the present figures are perhaps more an indication of the zeal and enthusiasm of Prof. C. P. Alexander than they are of the actual composition of the fauna.

This is the third major regional catalogue of Diptera to appear during the last nine years. When one considers that the last previous catalogues of such scope were those of Aldrich for Nearctic Diptera in 1905 and of Becker, Kertesz *et al* for Palaearctic Diptera and about half the world Diptera in 1902-1910, this flurry of catalogues is as remarkable as it is welcome. For taxonomists of Diptera, and indeed for all biologists interested in the order, these publications are of inestimable value. For all biological taxonomists they provide convincing evidence that the discipline, which Ehrlich in a famous forecast had seen as extinct by 1970, is alive and flourishing.

—*J. R. Vockeroth*

REARING NATURAL ENEMIES OF APHIDS FOR ECOLOGICAL STUDIES[1]

B. D. Frazer, D. Raworth and A. Bryan[2]

Introduction

Recent books on parasites of aphids (Starý, 1970) and on coccinellids (Hodek, 1973) include rearing methods but in passing only, when discussing the biology of the species concerned. A text on biological control (De Bach *et al.*, 1964) deals with rearing but like Smith (1966) it emphasizes economy in mass rearing and the use of artificial diets. We needed a system of rearing which was simple and efficient yet easily adapted to the different needs of Coccinellids, Chrysopids, Aphidiids and hyperparasites. We were not interested in long term or mass rearing but in rearing small numbers of different species just long enough to measure some biological attribute needed for our studies on the impact of natural enemies on the population dynamics of the prey. Because of the number of species to be reared, our philosophy is based on the view that the insects should do most of the work, which obviously saves labour and also seems to result in more vigorous insects. This paper reports our general methods and the modifications that have allowed us to maintain stocks of 3 parasites and 3 hyperparasites of aphids; 2 chrysophids and 7 coccinellids.

Methods and Discussion

The basic rearing system requires continuity in production of plants and aphids and a controlled, uniform environment. Stable conditions reduce the amount of attention needed by the colonies, permit accurate scheduling of the work and give predictable results.

[1]Contribution No. 324, Research Station, Vancouver.

[2]Present address: Agriculture Canada, Research Station, 6660 N. W. Marine Drive, Vancouver, B.C. V6T 1X2.

Plant and Aphid culture. We plant 10 broad bean seeds (*Vicia faba* L., cv. Exhibition Long Pod) per pot in UC mix C, Fertilizer I (Matkin and Chandler, 1957) in 15 cm round, plastic pots. This is done four times per week. When the plants are newly sprouted they are heavily infested with pea aphids, *Acyrthosiphon pisum* (Harris), and the pots are placed in a room maintained at 20 ± 2°, 60 ± 10% RH and provided with 1000 ± 100 lux of light, 16 hr per day (± indicates the normal ranges). The plants and aphids are ready for use in 7-8 days, when the plants are 20-40 cm high but are still actively growing. The pots of infested plants are then either moved into rearing cages or the aphids from the plants are harvested. It is advantageous to hold the aphid stock colonies in another room, distant from the parasite rearing area, otherwise the aphids must be caged.

We use UC mix because of its homogeneity and constant composition over time; but more importantly, one pot can retain about 500 cc of water and absorb this amount in 5-10 sec. This reduces watering to 2 times per week and minimizes the risk of accidental drought. The environmental conditions are ideal for the rapid production of high numbers of large pea aphids. The stock of aphids we use is an 'ecotype' selected over 15 years and is ideally suited to these conditions, In fact, it does poorly at 5° warmer or in cooler or dryer conditions.

Rearing cages. We use cages of varying sizes and construction. We have not found dimensions or shape to be important except for syrphids (Frazer, 1972), provided that the

cages have transparent roofs and forced air supply. Air movement is essential in maintaining constant favourable conditions inside the cages. A squirrel cage fan (1/6 hp) assembly fitted with a rheostat to control the flow, supplies air to the cages through cardboard or wooden ducts. The supply is minimal, only enough to prevent condensation and heat build up, yet insufficient to cause excessive evapotranspiration from the plants. A large number of cages can be supplied by one fan, provided that each cage is connected in parallel to a larger duct to give an equal air flow to the cages. We have one unit with 6 cages on both sides of a built-in air duct, from which another worker supplies air to 60 single pot cages, using the same small fan assembly. In fact, a plant in a plastic bag supplied with forced air makes a suitable temporary cage.

Rearing coccinellids. Field collected adults are placed in a cage with as many pots of aphid infested broad bean plants as the cage will hold. The object here is to adjust the ratio of adult coccinellids to the number of aphids on the actively growing plants so that the coccinellids neither eat all the aphids in a few days nor allow the aphids to increase greatly, thereby killing the plants. The starting ratio is not critical but a good ratio prevents unscheduled maintenance. A suitable ratio is 200 adults with 4 pots of 10 plants each.

The coccinellids will oviposit on the plants but handling eggs on plants involves considerable time and disturbance to the aphids. We found that coccinelids prefer to oviposit in crevices in the cages, in folded leaves and under the rims of pots. If single faced, corrugated, cardboard strips are placed in the cage with the corrugations running across the width, almost all egg laying will occur under and in the corrugations. Eggs deposited on exposed areas are soon eaten by the adults. Egg cannibalism is minimal with corrugated cardboard, unless the strips are left in the cage for days. If the strips are removed and replaced daily, vast numbers of eggs can be produced. However, we use the strips only to start another generation, which happens every other month.

The cardboard strips for oviposition have other advantages: large numbers of eggs are deposited in a short period thus allowing synchronization of hatching; and the cardboard has a large surface area to volume ratio. The last two factors greatly reduce the mortality caused by young larvae eating unhatched eggs of neighboring batches and by older larvae eating younger ones.

We put about 10 feet of the strips bearing eggs in a 1/2 gal ice cream carton and when the eggs are ready to hatch, after about five days, we add a surplus of aphids. When the larvae have moulted once, they and the cardboard strips are placed in a large cage and maintained like the adults. When the larvae reach the fourth instar, pots of aphid-infested plants must be added every 2-3 days to prevent cannibalism. Again the cardboard reduces mortality, because the larvae seek out secluded areas before moulting or pupating. Pupation, however, also occurs in other areas.

We have reared the following species using these methods: *Adalia bipunctata* L., *Coccinella californica* Mannerheim, *C. undecimpunctata* L., *C. trifasciata perplexa* Mulsant, *C. johnsoni* Casey, *Cycloneda munda* Say and a *Mulsantina* species.

Rearing chrysopids. We reared two *Chrysopa* species using essentially the same methods as for coccinellids. Corrugated cardboard is useful for chrysopids for the same reasons as for coccinellids, except that adults do

not oviposit on it preferentially. We simply ensure that cages of larvae are well supplied with the cardboard strips for moulting and pupating. The most important requirement is to use newly sprouted bean plants. This promotes synchronous rearing of the aphids with the chrysopid larvae.

Rearing parasites. We have reared *Aphidus ervi* Haliday, *A. smithi* Sharma and Subba Rao and *Praon pequedorum* Viereck.

Cannibalism does not occur with the parasites, which greatly simplifies rearing. Newly sprouted plants are used, 5-10 cm high, so that the aphids are reared in the cage with adult parasites. If more than 20 ♀ parasites are introduced into a new cage, they 'oversting' and eliminate the aphids; if fewer than 20 ♀ are used, aphid reproduction appears to keep up with oviposition pressure and thus ensuring a large number of parasites in the next generation. If too few parasites are used, the aphids increase rapidly and kill the plants before the parasites have time enough to pupate. If parasites of uniform age are needed, larger plants with more aphids are used. But here a large number of ♀ parasites are put in the cage and removed 24 hr later. Such synchronous colonies are essential for rearing hyperparasites.

The two *Aphidius* species present no problems, but *P. pequodorum* does well only when we shut off the air flow , place a dish of water in the cage and let honeydew accumulate. We add a previously heavily infested pot of plants to provide honeydew. Our experience is that messy cages promote good production of this sp. We supply honey as droplets on pieces of wax paper taped to the side of the cages for all parasite species.

Rearing hyperparasites. We have successfully reared *Asaphes vulgaris* Walker, *A. californicus* Girault and a *Dendrocerus sp.* on *Aphidus ervi* in pea aphids. The only problems are to synchronize the plant, aphid and primary parasite production; and to ensure the proper ratio of aphids to primary parasites. We use synchronous parasite rearing for this purpose. When the primary parasites are removed after 2-3 days association with the aphids, a maximum of 20 ♀ hyperparasites are added. The hyperparasites then oviposit in the previously parasitized aphids in the preferred stage of development. The cage conditions for *P. pequodorum* also suit the hyperparasites but honey is not essential.

Mass rearing conditions. The basic rearing systems described are easily upgraded to produce very large numbers of coccinellid eggs and parasite adults. From a young stock of 100 ♂ and 100 ♀ coccinellids, 500 eggs per day may be produced for up to four months. The maintenance involves at most 1 hr per week, much of which is spent in cutting cardboard. The eggs may be safely stored at 10°C for 10 days, but such treatment greatly increases the hatching time when they are returned to warmer conditions. The most critical aspect of the system is to have plants and aphids in excess, particulaly when coccinellid larvae are in their 3rd and 4th instars.

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NOTES ON THE BIOLOGY OF *CRAMPTONOMYIA SPENCERI* ALEXANDER (DIPTERA: CRAMPTONOMYIIDAE)

J. R. VOCKEROTH[1]

[1]Biosystematics Research Institute
Agriculture Canada, Ottawa

ABSTRACT

Adults of **Cramptonomyia spenceri** were abundant in the lower Fraser Valley, British Columbia, from late February to early April of 1973. Eggs, larvae and pupal skins were found on or in dead fallen stems of **Alnus rubra.** Wing frequency measurements of both sexes indicate that auditory stimuli are not involved in finding of mates.

Cramptonomyia spenceri Alexander 1931 was described from a female collected in Vancouver, B.C. on 30 March, 1930 by the late professor G. J. Spencer. Alexander referred it to the family Bibionidae, but thought that it might belong to the family Pachyneuridae, a family with the single Palaearctic species *Pachyneura elegans* Zetterstedt. In 1965 Alexander referred *Cramptonomyia* to the Pachyneuridae. Hennig (1969) proposed a family Cramptonomyiidae for *Cramptonomyia* and the Japanese species *Harukea elegans* Okada. Krivosheina and Mamajev (1970) described the larva, pupa, male and female of *Pergratospes holoptica*, a third species of the family Cramptonomyiidae and the first of which the immature stages were known. The larvae were found under bark of dead but standing *Maackia amurensis* trees (Leguminosae) in the Ussuri district, Maritime Territory, Siberia. In my opinion all four genera mentioned above are closely related and should be referred to the family Pachyneuridae.

Additional specimens of *C. spenceri* were collected in the University of British Columbia (UBC) Forest, Vancouver by J. K. Jacob, at Langley Prairie, B.C. by K. Graham (Jacob, 1937), and in the campus forest in 1942 by R. E. Foster (UBC collection). Alexander (1965) recorded the species also from Washington and Oregon. He told me (in *litt.*) that he has no record of the Washington locality, but the Oregon specimens were taken by K. E. Fender in northwestern Oregon at Wallace Bridge, 31. III. 1948 and near the coast at Castle Rock, on the Grande Ronde-Hebo highway, 31. III. 1949.

From 28 February to 6 April, 1973 I collected about 400 adult *Cramptonomyia* in the lower Fraser Valley of British Columbia. They were taken mostly at Point Grey (Vancouver), but also on Mt. Seymour (North Vancouver), at Hope and at White Rock, at altitudes from sea level to 400 m. They were taken in moderate numbers in mixed conifer and deciduous forest (Fig. 1) at all these localities, but in large numbers in an almost pure stand of young red alder, *Alnus rubra*, along Chancellor Blvd. on the UBC endowment lands on Point Grey (Fig. 4). The largest numbers were taken here on 20 March which indicates either considerable longevity or a prolonged emergence period. The number of adults at this locality declined rapidly after this date; extensive sweeping on 6 April yielded one male. A woodland where the species was not found was a mixture of *Betula* and *Pinus contorta* on Lulu Island in the Fraser River delta. Twenty min-

[1]Biosystematics Research Institute, Agriculture Canada, Ottawa.

Fig. 1. Mixed conifer and deciduous forest, UBC endowment lands, Point Grey, Vancouver.
Fig. 2. Female of **Cramptonomyia spenceri.**
Fig. 3. Male of **C. spenceri.**
Fig. 4. Pure stand of young red alder, **Alnus rubra,** UBC endowment lands, Point Grey, Vancouver.

utes of sweeping in early March produced no specimens.

After these collections were made I learned that Mr. William Dean, of Simon Fraser University (SFU), Burnaby, B.C. has for several years taken specimens of *Cramptonomyia* on the windows of the university buildings. He thought the insects were more abundant in 1973 than in previous years. The SFU campus is surrounded by second growth alders but these are mostly several hundred meters away so it appears that the flies sometimes leave the forested areas where they breed.

Females confined in vials with pieces of rotten wood laid from one to 66 eggs each. Fallen alder stems, referred to here as logs, from the stand on Chancellor Blvd. were found to have many eggs on the surface. The logs varied in diameter from 3 to 12 cm. Eggs occurred on all surfaces of the logs; most were in crevices or along the edges of broken pieces of bark, but some were on bare wood or on unbroken bark. The logs ranged in condition from quite hard to rather soft and rotten. The eggs were laid singly but the density varied considerably. The greatest abundance observed was 54 on one log 35 cm in length and about 5 cm in diameter. Four dead standing trunks were examined but the single egg found was about 3 cm above the ground. Eggs (Figs. 5-7) are orange-brown, 0.95 mm long and 0.25 mm in greatest width. The surface is very strongly sculptured.

A first instar larva (Fig. 8) was found on 29 April on a log stored at 6°C for about one month. By 8 May logs from the field had approximately 90% of the eggs hatched; one hatched on that date while the log was being examined. The age of the eggs was not known but since they were abundant in late March the incubation period under field conditions is probably at least six weeks. Larvae could usually be found near empty egg shells either in a shallow burrow under nearby bark or, if no bark was present, in a burrow about 1 mm below the surface of the wood. On 18 June empty egg shells and larvae, apparently still in the first instar, were found on field-collected logs.

In late March two larger larvae, 11.8 and 12.2 mm long, were found in alder logs. The position in the logs was not determined. These larvae were about the same length as the adults. Mature larvae of the Siberian *Pergratospes* are about twice as long as adults, so these *Cramptonomyia* larvae were probably about half grown. It seems probable therefore that the life cycle takes at least two years.

During late March and early April empty pupal skins were found protruding from alder logs. The two larvae mentioned, and the pupal skins, are almost identical with those described for *Pergratospes* and are therefore undoubtedly those of *C. spenceri.* About the anterior third of the pupal skin protrudes from the tunnel, which runs parallel to the surface of the wood and about 2 mm below it. The tunnel is clear for about 2 cm and is then packed with frass. At the outer end of the frass the head capsule and sometimes the cast larval skin of the last instar can be found. Pupal skins were found only in logs soft enough to be broken easily by hand. Dr. R. S. Smith, Western Forest Products Laboratory, Department of the Environment, Vancouver, examined several of these and estimated that they had been on the ground for at least three and possibly four years. Pupal skins were found in logs ranging from 3.1 to 11.3 cm in diameter.

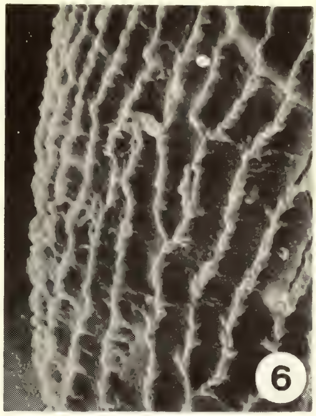

Fig. 5. Egg of **C. spenceri** (stereoscan photograph, X 55).
Fig. 6. Surface of egg of **C. spenceri** (stereoscan photograph, X 275).
Fig. 7. Surface of egg of **C. spenceri** (stereoscan photograph, X 1100).
Fig. 8. First instar larva of **C. spenceri** in opened burrow.

Almost all adults taken were swept from vegetation up to about 1 m above the ground. A few were seen flying slowly at heights up to about 2 m. Consistently more males than females were collected; the most marked imbalance was 113 males and 7 females collected on 20 March. However, the pupal skins of 23 males and 19 females were found, so it is probable the sexes are produced in about equal numbers.

Mating was not observed. The antenna of the male (Fig. 4) is very much longer than that of the female (Fig. 3). I thought it possible that the male antenna might function as

an auditory organ which would respond to the sound produced by the female during flight. Dr. Peter Belton, Department of Biological Sciences, SFU, determined the wing frequency of two specimens of each sex. He gave me the following information:

Sound was recorded with a Sony ECM condenser microphone and a Sony 355 tape deck at a temperature of $21 \pm 1°C$. Owing to the low frequency of the wing beat, sound pressure showed above the noise level only when the insects were within about 2 cm of the microphone (± 56 db SPL). Frequency of individuals varied about 5% during flight. Males and females flying together could not be distinguished by an experienced human ear. Three readings for each of the four specimens gave the following averages: male 1, 74 Hz; male 2, 52 Hz; female 1, 60 Hz; female 2, 56 Hz. In those Diptera Nematocera (e.g. some Culicidae, Chironomidae, Ceratopogonidae) in which males respond to auditory stimuli produced by the females, the wing frequency of the sexes is markedly different. It is therefore very unlikley that the males of *Cramptonomyia* respond to auditory stimuli from the females.

In *Pergratospes holoptica* the eyes of the male are much larger than those of the female and visual recognition in flight is probably involved in the finding of a mate. The eyes of both sexes of *Cramptonomyia* are of about the size of those of the female of *Pergratospes* so it is unlikely that the male recognizes the female in this manner.

The long male antennae may carry chemoreceptors which respond to a pheromone produced by the female. The female palpi are about twice as long as those of the male, an unusual and possibly even unique condition in the Nematocera, but their function is unknown. Further observations are required to determine the reasons for the marked sexual dimorphism in the length of antennae and palpi.

Acknowledgements

I wish to thank Mr. J. H. Severson, Research Station, Agriculture Canada, Vancouver for the photographs of adults and larva, and Dr. A. R. Forbes and Mr. F. Skelton, of the same Station, for the photographs of the egg.

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THE APHIDS (HOMOPTERA: APHIDIDAE) OF BRITISH COLUMBIA 3. ADDITIONS AND CORRECTIONS[1]

A. R. FORBES, B. D. FRAZER AND CHO-KAI CHAN
Research Station, Agriculture Canada
Vancouver, British Columbia

ABSTRACT

Forty-eight species of aphids are added to the basic taxonomic list of the aphids of British Columbia. New host records, corrections, and some name changes are also included.

Introduction

The basic taxonomic list of the aphids of British Columbia was published last year in this Journal (Forbes, Frazer, and MacCarthy 1973). That list recorded 213 species collected from 255 hosts or in traps.

The present list adds 48 species of aphids (indicated with an asterisk in the list) and 128 aphid-host plant associations to the first list. Thirty-nine of the new aphid-host plant combinations involve plant species not in the previous list. The additions recorded here bring the number of known aphid species in British Columbia to 261.

This new information is based on collections made by the staff of the Vancouver Research Station, on records supplied by Dr. A. G. Robinson of material he collected in British Columbia, and on records supplied by Dr. G. A. Bradley of *Cinera* species collected in the province. Five records from literature are included.

The present paper also includes certain corrections to the basic taxonomic list and some changes in generic and specific names in conformity with current usage in aphid taxonomy.

As in the previous list, the aphids are arranged alphabetically by species. The location of each collection site can be determined from Table 1 of the basic list or from Table 1 of the present list. The reference points are the same as those shown on the map which accompanies the basic list.

[1]Contribution No. 325, Research Station, 6660 N. W. Marine Drive, Vancouver, British Columbia, V6T 1X2.

Table 1. Localities where aphids were collected, with airline distances from 8 reference points.

Locality	Reference point	Dir.	Distance km	Distance mi
Alice Lake	Vancouver	N	53	33
Barkerville	Williams Lake	NE	114	71
Boston Bar	Vancouver	NE	144	90
Boulder Creek	Creston	E	107	67
Cascade	Creston	W	125	78
Clearwater	Kamloops	NE	110	69
Comox	Victoria	NW	179	112
Cordova Bay	Victoria	E	5	3
Cowichan Lake	Victoria	NW	83	52
Dawson Creek	Prince George	NE	259	162
Englishman River Falls Park	Victoria	NW	114	71
Granite Falls	Vancouver	NE	34	21
Horseshoe Bay	Vancouver	N	13	8
Jordan River	Victoria	W	50	31
Kaslo	Creston	N	96	60
Keremeos	Kelowna	S	78	49
Kootenay Park	Creston	N	72	45
Malakwa	Kamloops	E	112	70
Nanaimo	Victoria	NW	91	57
Nitinat Lake	Victoria	W	102	64
Okanagan Lake	Kelowna	N	21	13
Princeton	Vancouver	E	198	124
Radium Hotsprings	Creston	N	176	110
Rutland	Kelowna	N	6	4
Sechelt	Vancouver	NW	45	28
Shingle Creek	Kelowna	S	45	28
Shuswap Falls	Kamloops	NE	69	43
Shuswap Lake	Kamloops	NE	50	31
Slocan	Creston	NW	104	65
Surrey	Vancouver	E	24	15
Tofino	Victoria	NW	202	126
Trout Creek	Kelowna	S	37	23
Tsawwassen	Vancouver	S	29	18
Vernon	Kelowna	N	48	30
Westbank	Kelowna	W	13	8

LIST OF SPECIES

ABIETICOLA (Cholodkovsky), CINARA
Abies grandis: Chilliwack, Jun 9 / 64.
Abies lasiocarpa: Vernon, Jun 16 / 56.

ABIETINUM (Walker), ELATOBIUM
Picea sp: Vancouver, Mar 11 / 73, May 16 / 73.

AEGOPODII (Scopoli), CAVARIELLA
Apium graveolens: Cloverdale, Aug 7 / 59, Aug. 18 / 59.
Daucus carota: Cloverdale, Jun 19 / 59; Saanich, Jul 10 / 59; Vancouver, Aug 6 / 66.
Pastinaca sativa: Vancouver, May 23 / 58.

AGATHONICA Hottes, AMPHOROPHORA
Previously listed as AMPHOROPHORA RUBI (Kaltenbach).

ALBIFRONS Essig, MACROSIPHUM
Lupinus sp: Vancouver, Aug 3/66.

ALNI (DeGeer), PTEROCALLIS
Alnus rubra: Granite Falls, Jun 26 / 66: Vancouver (UBC), Aug 25/72.

ALNIFOLIAE Williams, PROCIPHILUS
Previously listed as PROCIPHILUS CORRUGATANS (Sirrine).

AMBROSIAE (Thomas), DACTYNOTUS
Hypochoeris radicata: Vancouver (UBC), Aug 25/72.

*ANNULATUS (Hartig), TUBERCULOIDES
Quercus robur: Chilliwack, Jun 22 / 66; Vancouver, Aug 29/72.

*ARIZONICA (Wilson), CINARA
Pinus ponderosa: Okanagan Lake, Jun 18/62.

*ARUNDINARIA (Essig), TAKECALLIS
Pseudosasa japonica: North Vancouver, Oct 7/72.

ATRIPLICIS (Linnaeus), BRACHYCOLUS
Chenopodium album: Grand Forks, Jul 29/59.

AVENAE (Fabricius), MACROSIPHUM
Avena sativa: Agassiz, Aug 2/57; Creston, Jul 31/57; Vancouver, Jul 2/57, Aug 29/57; Vancouver (UBC), Jun 5/58, Aug 1/56.

* Aphid species not in the previous list.

BERBERIDIS (Kaltenbach), LIOSOMAPHIS
Berberis thunbergii: Chilliwack, Jun 7/64.

*BETULAECOLENS (Fitch), CALAPHIS
Betula sp: Vancouver, May 16/59.

BETULICOLA (Kaltenbach), CALAPHIS
Betula pendula: Victoria, Aug 2/65.

BICOLOR BICOLOR (Oestlund, PTEROCOMMA
Populus trichocarpa: Summerland, Sep 5/65.

BRAGGII (Gillette), CINARA
Previously listed as BRAGGI due to a typographical error.
Picea abies: Chilliwack, Jun 7/64.
Picea sitchensis: Nitinat Lake, Jun 2/56.

BRASSICAE (Linnaeus), BREVICORYNE
Brassica napobrassica: Barnhartvale, Oct 4 / 56; Cloverdale, Aug 30/ 56; Cordova Bay, Aug 11/ 53; Ladner, Aug 29/ 56; Saanich, Aug 21 / 60; Surrey, Aug 29/56.
Brassica oleracea var *capitata:* Agassiz, Jul 16/58.
Brassica oleracea var *gemmifera:* Abbotsford, Sep 13 / 65; Vancouver, Feb 25 57.

*BREVIPILOSA Börner, BETULAPHIS
Betula sp: Vancouver, Jul 13/59.

BREVISPINOSA (Gillette & Palmer), CINARA
Pinus contorta: Cowichan Lake, Jun 8/56.

BULBOSA (Richards), FULLAWAYA
Previously listed as PLOCAMAPHIS BULBOSA Richards.

CALIFORNICUM (Clarke), MACROSIPHUM
Salix sp: Chilliwack, Jun 8/64.

CALIFORNIENSIS (Shinji), PERIPHYLLUS
Acer circinatum: Vancouver, May 16/73; Vancouver (UBC), May 21/73.
Acer negundo: Vancouver, May 13/73.

*CANADENSIS Robinson, KAKIMIA
Lonicera involucrata: Granite Falls, Jun 26/66 (Robinson, 1968).

*CAPILANOENSIS Robinson, AULACORTHUM
Rubus spectabilis: Vancouver, Jul 19/68 (Robinson, 1969).

*CARAGANAE (Cholodkovsky), ACYRTHOSIPHON
Colutea arborescens: Vancouver (UBC), Apr 26/72.

CEANOTHI Clarke, APHIS
Ceanothus velutinus: Clearwater, Aug 29/71.

CERASI (Fabricius), MYZUS
Prunus avium: Victoria, Jun 5/59.
Prunus cerasifera: Chilliwack, Jun 25/66.
Prunus sp: Oliver, Jun 3/56.

*CERASIFOLIAE (Fitch), RHOPALOSIPHUM
Prunus sp: Soda Creek, Jun 15/56.
Prunus virginiana var *demissa:* Penticton, Sep 3/65; Williams Lake, May 15/56.

*CERTUS (Walker), MYZUS
Spergularia rubra: Vancouver, Sep 14/72.

*CHRYSOTHAMNI Wilson, APHIS
Chrysothamnus nauseosus: Summerland, Jul 26/68.

CIRCUMFLEXUS (Buckton), AULACORTHUM
Chrysanthemum morifolium: Vancouver, Jun 14/66 (in greenhouse).

COLORADENSIS (Gillette), CINARA
Picea sitchensis: Comox, May 23/62.

COLUMBIAE Richards, SITOMYZUS
Agropyron repens: Vancouver, May 18/58.

CORYLI (Goeze), MYZOCALLIS
Corylus sp: Vancouver, Aug 7/66.

COSTATA (Zetterstedt), CINARA
Picea glauca: Boulder Creek, Jul 15/58.

CRYSTLEAE (Smith & Knowlton), MASONAPHIS
Previously listed as CRYSTLEA due to a typographical error.

CURVIPES (Patch), CINARA
Abies grandis: Cowichan Lake, Jun 27/56.

*CURVISPINOSUS, Hottes, Essig & Knowlton, SCHIZOLACHNUS
Pinus ponderosa: Slocan, Jul 5/63.

CYPERI (Walker), TRICHOCALLIS
Carex sp: Vancouver, Sep 25/72.

CYTISORUM Hartig, APHIS
Laburnum watereri: Chilliwack, Jun 7/64.

DIRHODUM (Walker), ACYRTHOSIPHON
Previously listed as METOPOLOPHIUM DIRHODUM (Walker).
Avena sativa: Vancouver, Jul 2/57; Vancouver (UBC), Jun 5/58.
Rosa sp: Erickson, Oct 8/58; Ladner, Jan 7/56; Vancouver, Mar 21/73, Mar 25/73, Apr 23/66.

ERIOPHORI (Walker), CERURAPHIS
Carex sp: Vancouver, Sep 28/72.

ERYSIMI (Kaltenbach), HYADAPHIS
Brassica oleracea var *gemmifera:* Agassiz, Aug 22/58.
Sisymbrium officinale: Vancouver, Jul 24/68.

ESSIGI (Gillette & Palmer), KAKIMIA
Aquilegia sp: Vancouver, Sep 7/72.

EUPHORBIAE (Thomas), MACROSIPHUM
Brassica oleracea var *gemmifera:* Agassiz, Aug 22/58; Vancouver, Jul 18/58.
Chenopodium album: Agassiz, Jul 12/56; Brentwood, Jul 5/59.
Chrysanthemum morifolium: Vancouver, Aug 22/58.
Geum macrophyllum: Vancouver, Sep 26/72.
Hypochoeris radicata: Vancouver (UBC), Aug 25/72.
Lactuca sativa: Cloverdale, May 15/59, May 26/59, Jun 12/59, Jun 22/59.
Rosa rugosa: Vancouver (UBC), Jul 15/59.
Rosa sp: Brentwood, Jun 5/59; Creston, May 4/59; Milner, Jun 10/59; Pemberton, Aug 24/56; Soda Creek, Jun 15/56; Vancouver, Jun 17/59.

FABAE Scopoli, APHIS
Bidens cernua: Vancouver, Sep 9/72.
Chenopodium album: Brentwood, Jul 5/59; Ladner, Sep 25/56; Lulu Island, Jul 8/58; Vancouver, Jul 7/56.
Impatiens glandulifera: Horseshoe Bay, Aug 14/72.

Lactuca sativa: Cloverdale, Aug 7/ 59, Aug 18/59.
Matricaria matricarioides: Vancouver, Aug 29/72.
Meconopsis cambrica: Vancouver, Aug 27/72, Sep 17/72.
Myosotis arvensis: Vancouver, Sep 17/ 72.

FAGI (Linnaeus), PHYLLAPHIS
Fagus grandifolia: Chilliwack, Jun 22/66.

*FARINOSA Gmelin, APHIS
Salix sitchensis: Vancouver, Jun 27/ 56.
Salix sp: Boston Bar, Jul 14/ 56; Granite Falls, Jun 26/66; Kootenay Park, Jul 26/67.

*FERRISI (Swain), CINARA
Pinus monticola: Sechelt, Aug 22/56.

FIMBRIATA Richards, FIMBRIAPHIS
Rosa sp: Ladner, Jun 7/ 56; Milner, Jun 10/59; Soda Creek, Jun 15/ 56; Vancouver, Jun 17/59.
Vaccinium sp: Richmond, Jul 21/72.

FLAVA (Davidson), OESTLUNDIELLA
Alnus sp: Alice Lake, Jun 21/68.
Alnus tenuifolia: Penticton, Sep 5/65.

FORBESI Richards, AMPHOROPHORA
Previously listed as FORBESI (Richards) due to a typographical error.

FORNACULA Hottes, CINARA
Picea sitchensis: Tofino, Jun 24/62.
Picea sp: Vancouver, May 29/73.

FRAGAEFOLII (Cockerell), CHAETOSIPHON
Rosa sp: Ladner, Jun 7/ 56; Soda Creek, Jun 15/56.

FRAGARIAE (Walker), MACROSIPHUM
Calamagrostis sp: Vancouver, Jul 24/68.
Gramineae: Surrey, Jul 7/59.
Rubus sp: Vancouver (CDA), Jun 21/72 (in rearing room).

GILLETTEI Davidson, EUCERAPHIS
Alnus rubra: Vancouver (UBC), Nov 17/72.
Betula sp: Chilliwack, Jul 21/59.

HELICHRYSI (Kaltenbach), BRACHYCAUDUS
Anaphalis margaritacea: Granite Falls, Jun 26/66.
Chrysanthemum frutescens: Vancouver, Apr 30/58.
Chrysanthemum morifolium: Vancouver, Jan 13/57, Jan 14/57, May 28/59, Dec 25/52.
Gnaphalium uliginosum: Vancouver, Sep 12/72.
Prunus domestica: Vancouver, May 12/58, May 26/56; Victoria, Jun 5/59.

HIPPOPHAES (Walker), CAPITOPHORUS
Polygonum persicaria: Vancouver, Sep 9/72.

*HOTTESI (Gillette & Palmer), CINARA
Picea glauca: Shuswap Falls, Jun 10/59.

HUMILIS Walker, HYALOPTEROIDES
Previously listed as HYALOPTEROIDES DACTYLIDIS (Hayhurst).

HUMULI (Schrank), PHORODON
Prunus cerasifera var *pissardii:* Chilliwack, Jun 8/64.

*INSCRIPTA Hottes & Essig, CINARA
Pinus albicaulis: Westbank, Jun 13/56.

*INTERMEDIUS Gillette & Palmer, SYMYDOBIUS
Betula occidentalis: Shingle Creek, Sep 5/65.

KIOWANEPUM (Hottes), MACROSIPHUM
Previously listed as KIOWANEPHUM due to a typographical error.

KONOI Takahashi, CAVARIELLA
Apium graveolens: Victoria, Aug 6/53.

*KUCHEA Hottes, CINARA
Pinus monticola: Kaslo, Jun 22/56.

LACTUCAE (Linnaeus), HYPEROMYZUS
Sonchus asper: Vancouver (UBC), Aug 10/72.

*LACTUCAE (Passerini), ACYRTHOSIPHON
Lactuca serriola: Saanich, Aug 21/59.

LANIGERUM (Hausmann), ERIOSOMA
Cotoneaster sp: Vancouver (UBC), Oct 22/69.

*LARICIFOLIAE (Wilson), CINARA
Larix occidentalis: Lumby, Jun 16/62.

*LIGUSTRI (Mosley), MYZUS
Ligustrum vulgare: Vancouver, May 30/59, Aug 25 69.

MACROSTACHYAE (Essig), CHAITOPHORUS
Salix argophylla: Penticton, Sep 3/65.

MAIDIS (Fitch), RHOPALOSIPHUM
Hordeum vulgare: Dawson Creek, Aug 3/60.

MAXIMA (Mason), MASONAPHIS
Rubus parviflorus: Chilliwack, Jun 25/66.

MEDISPINOSA (Gillette & Palmer), CINARA
Pinus contorta: Lumby, Jun 16/62.

*MONELLI (Essig), CHAITOPHORUS
Salix sp: Creston, Aug 13/58.

*MONOPHAGUS Maxson, PEMPHIGUS
Populus sp: Quesnel, Jul/46.

*MULTISETIS Boudreaux & Tissot, MYZOCALLIS
Quercus coccinea: Chilliwack, Jun 7/64.

MURRAYANAE (Gillette & Palmer), CINARA
Pinus contorta: Jordan River, Jun 2/55.

NEGLECTUS Hottes & Frison, CHAITOPHORUS
Populus tremuloides: Radium Hotsprings, Jul 26/67.

NERVATA (Gillette), WAHLGRENIELLA
Rosa sp: Ladner, Jun 7/56; Soda Creek, Jun 15/56.

NIGRAE Oestlund, CHAITOPHORUS
Salix sp: Princeton, Sep 7/65.

*NIGRIPES Bradley, CINARA
Picea sitchensis: Comox, May 23/62.

*NIGROMACULOSUM Macdougall, MACROSIPHUM
Rosa nutkana: Summerland, Sep 5/65.

*OBSCURA Bradley, CINARA
Picea engelmannii: Barkerville, Jul 4/62.

OCCIDENTALIS (Davidson), CINARA
Abies grandis: Duncan, Jun 4/56.

*OREGONI Hottes & Essig, CINARA
Pinus albicaulis: Westbank, Jun 29/62.

ORNATUS Laing, MYZUS
Chrysanthemum morifolium: Vancouver, Feb 12/58.
Viola tricolor: Vancouver, Aug 6/66.

PADI (Linnaeus), RHOPALOSIPHUM
Avena sativa: Vancouver, Aug 29/57.
Prunus domestica: Vancouver (UBC), May 23/56.
Scirpus sp: Clearwater, Aug 29/71.

*PATRICIAE Robinson, MASONAPHIS
Tsuga heterophylla: Vancouver, Jul 19/68 (Robinson, 1969).

PERGANDEI (Wilson), CINARA
Pinus contorta: Cascade, Jul 29/59.

PERSICAE (Sulzer), MYZUS
Apium graveolens: Creston, Apr 22/59.
Bidens cernua: Vancouver, Sep 9/72.
Brassica oleracea var *capitata:* Saanich, Aug 21/59.
Brassica oleracea var *gemmifera:* Agassiz, Jul 14/59, Jul 29/60; Vancouver, Jul 18/58.
Chenopodium album: Vancouver, Jul 7/56.
Cuscuta sp: Vancouver, Jul 13/72 (in greenhouse); Vancouver (CDA), May 25/71 (in rearing room).
Galium aparine: Langley, Apr 19 73.
Lactuca sativa: Cloverdale, May 26/59, Aug 7/59, Aug 18/59; Oliver, Jun 3/56.
Prunus domestica: Summerland, Aug 2/56.
Sisymbrium officinale: Vancouver, Jul 24/68.

*PHILADELPHI MacGillivray, GLENDENNINGIA
Philadelphus gordonianus: Agassiz, Jun 22/51 (MacGillivray, 1954).

PISUM (Harris), ACYRTHOSIPHON
Lupinus sp: Vancouver, no date.

PANTAGINEA (Passerini), DYSAPHIS
Malus sylvestris: Vancouver, Jun 27/72; Vancouver (UBC), Apr 27/72; Victoria, Jun 5/59.

PLATANOIDES (Schrank), DREPANOSIPHUM
Acer macrophyllum: Vancouver, May 24/73.
Acer platanoides: Chilliwack, Jun 7/64.

POMI DeGeer, APHIS
Cotoneaster sp: Vancouver, Sep 15/72.
Crataegus sp: Vancouver, Sep 19/56.
Malus sylvestris: Vancouver, Jun 30/72.

*PONDEROSAE (Williams), CINARA
Pinus ponderosa: Vernon, Jun 13/56.

POPULICOLA (Thomas), CHAITOPHORUS
Populus sp: Soda Creek, Jun 15/56.
Populus tremuloides: Kamloops, Jul 1/36.
Populus trichocarpa: Summerland, Sep 5/65.

POPULIFOLII (Essig), CHAITOPHORUS
Populus trichocarpa: Summerland, Sep 5/65; Vancouver, Aug 11/57; Vancouver (UBC), Jun 27 56.

POPULIMONILIS (Riley), THECABIUS
Populus trichocarpa: Princeton, Jul 28/67.

POPULIVENAE Fitch, PEMPHIGUS
Lactuca sativa: Agassiz, Jul 12/56; Chilliwack, Aug 10/59; Cloverdale, Jun 22/59.
Populus sp: Cloverdale, Jun 15/59.

PRUNI (Geoffroy), HYALOPTERUS
Prunus domestica: Summerland, Sep 3/65.

*PSEUDAMBROSIAE Olive, DACTYNOTUS
Lactuca biennis: Vancouver (UBC), Sep 1/72.

PSEUDOTAXIFOLIAE Palmer, CINARA
Pseudotsuga menziesii: Cowichan Lake, May 12/56.

*PSEUDOTSUGAE (Wilson), CINARA
Pseudotsuga menziesii: Shuswap Lake, Jun 11/59.

PUNCTIPENNIS Zetterstedt, EUCERAPHIS
Betula occidentalis: Keremeos, Jul 28/67.
Betula sp: Burnaby, Apr 6/61; Lulu Island, May 4/65.

QUADRITUBERCULATA (Kaltenbach), BETULAPHIS
Betula pendula: Trout Creek, Sep 3/65.
Betula sp: Chilliwack, Jul 21/59.

*RANDYKEI Wilson, CINARA
Picea sitchensis: Nitinat Lake, Jun 10/56.

RHAMNI Clarke, MACROSIPHUM
Rhamnus purshiana: Vancouver, May 24 73; Victoria, May 20/73.

*RICHARDSI MacGillivray, MASONAPHIS
Anaphalis margaritacea: Vancouver, Jul 19/68.

RIEHMI (Börner), THERIOAPHIS
Does not breed on *Medicago;* those previously recorded on *Medicago* were almost certainly strays from *Melilotus.*

ROSAE (Linnaeus), MACROSIPHUM
Rosa rugosa: Vancouver (UBC), Jul 15/59.
Rosa sp: Milner, Jun 10/59; Soda Creek, Jun 15/56; Vancouver, Jan 7/57, Apr 23/66, Jun 21/67, Jul 24/57, Aug 18/72.

*ROSAE Richards, PSEUDOCERCIDIS
Rosa sp: Ladner, Jun 7/56.

*ROSETTEI Maxson, ASIPHUM
Betula papyrifera: Manning Park, Sep 7/65.

RUBITOXICA Knowlton, AMPHOROPHORA
Previously listed as RUBITOXICA (Knowlton) due to a typographical error.
Rubus vitifolius: Chilliwack, Jun 25/66.

RUSSELLAE Hille Ris Lambers, DACTYNOTUS
Anaphalis margaritacea: Alice Lake, Jul 21/68.

*SABINAE (Gillette & Palmer), CINARA
Juniperus scopulorum: Rutland, Jun 15/62.

SALICIS (Linnaeus), PTEROCOMMA
Populus sp: Soda Creek, Jun 15/56.

SALIGNUS (Gmelin), TUBEROLACHNUS
Salix sp: Vancouver, Sep/32.

SAMBUCIFOLIAE Fitch, APHIS
Sambucus racemosa var *pubens:* Vancouver, Jul 20/68.

SANBORNI Gillette, MACROSIPHONIELLA
Chrysanthemum morifolium: Vancouver, Jun 29/58, Jul 27/58, Aug 22/58.

*SANGUICEPS Richards, PTEROCOMMA
Salix babylonica: Vancouver, Jul 25/65 (Richards, 1967).
Salix sp: Nanaimo, Aug 6/65; Terrace, Jul 5/60 (Richards, 1967).

*SASKENSIS Bradley, CINARA
Picea engelmannii: Malakwa, Jun 14/62.

SETOSA (Kaltenbach), CTENOCALLIS
Cytisus scoparius: Victoria, Aug 25/71.

*SIJPKENSI Hille Ris Lambers, MACULOLACHNUS
Rosa sp: Soda Creek, Jun 16 56.

SOLANI (Kaltenbach), AULACORTHUM
Apium graveolens: Creston, Apr 22/59.
Daucus carota: Cloverdale, Jun 19/59.
Geranium sp: Vancouver, Nov/68.

*SONATA Hottes, CINARA
Abies grandis: Englishman River Falls Park, Jun 17/55.
Abies sp: Tsawwassen, Jul 5/71.

*SPINOSUS Shimer, HAMAMELISTES
Betula sp: Unknown location, Jun 20/72.

SPIRAEAE (MacGillivray), MASONAPHIS
Previously listed as SPIRAEA due to a typographical error.

SPLENDENS (Gillette & Palmer), CINARA
Pseudotsuga menziesii: Chilliwack, Jun 8/64; Cowichan Lake, May 16/56.

STANLEYI (Wilson), MACROSIPHUM
Sambucus racemosa var *pubens:* Vancouver, Jul 20/68.

TESTUDINACEA (Fernie), PERIPHYLLUS
Acer circinatum: Vancouver, May 24/73; Vancouver (UBC), May 21/73.
Acer macrophyllum: Vancouver, May 12/73, May 24/73.
Acer negundo: Chilliwack, Jun 8/64; Vancouver, May 13/73.
Acer sp: Vancouver, May 13/73; Vancouver (UBC), May 11/73.

TETRARHODUS (Walker), CHAETOSIPHON
Rosa sp: Vancouver (UBC), Sep 19/56.

*THATCHERI Knowlton & Smith, CINARA
Pinus ponderosa: Okanagan Lake, Jun 18/62.

*TRIRHODUS (Walker), LONGICAUDUS
Aquilegia sp: Vancouver, Sep 7/72.

*TSUGAE Bradley, CINARA
Tsuga heterophylla: Cowichan Lake, Jun 6/56.

*VARIANS Patch, APHIS
Epilobium anagallidifolium: Granite Falls, Jun 26/66.

VERRUCOSA (Gillette), ALLAPHIS
Carex sp: Vancouver, Sep 25/72, Sep 28/72.

VIMINALIS Monell, CHAITOPHORUS
Salix sp: Creston, Aug 13/58.

*WILSONI Hottes, ESSIGELLA
Pseudotsuga menziesii: Campbell River, Jun 22/62.

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